WHAT EVERY OWNER SHOULD KNOW

ABOUT HIS

# AUTOMOBILE

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A Practical Treatise on the Management and Operation of the Automobile. Also a safe Buying Guide for the Automobile and Accessory Buyer. Together with more than 500 Practical Suggestions Regarding Common Automobile Troubles and their Remedies. A Glossary of Automobile Terms and Complete Indexes to both Text and Advertisers.

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NEW YORK
AUTO-MERCURY PUBLISHING CO., Inc.
220 West 42nd Street
1914

*Price: Two Dollars*

# FOREWORD

THERE is a twofold object in publishing this book: First, to meet an urgent need for a *practical* handbook for everyone who owns or operates a motor car; secondly, to afford a means of bringing the autoist in direct touch with the most reliable manufacturers of automobiles, accessories, and other necessities or luxuries that every automobile owner purchases from time to time.

¶ The more you know about your motor car, whether you run it or not, the more economical will be its upkeep, and the greater your pleasure from its use.

¶ We know that the average book of this class is as hard to understand as the mechanism of the car itself; therefore, we believe that you and thousands of other enthusiastic motorists will appreciate this book, *which is intensely practical,* and devoid of all possible technical terms, yet so thorough as to be of valuable service to the amateur, as well as the most experienced in car operation.

¶ Prominent automobile engineers to whom preliminary proofs have been submitted unanimously pronounce it to be the most thorough and practical book of its kind published.

¶ There's hardly a detail about your car that it does not cover—it not only offers a practical remedy for every auto trouble, but it is also your safest guide to the avoidance of automobile troubles.

¶ *We want you to study it carefully, no matter what car you own. Be guided by the advice contained herein, to a greater appreciation of your car and its most economical operation.*

¶ *The Author and Publishers have maintained the strictest censorship over all advertising. Therefore, you can safely make it your Buying Directory,* for every automobile, accessory, or other article advertised herein is of a character and quality that merits your patronage.

¶ *Keep this Book at hand. Consult it frequently. Patronize its advertisers.*

¶ You are certain of the greatest satisfaction if you do, and you will have shown full appreciation of our effort to give you—free of cost—a *Book that will be of every-day Service to you.*

THE ADVERTISERS AND PUBLISHERS.

# TABLE I. OVERSIZE TIRES.

| Regular Size. | Over-size. | Oversize Sizes to Fit the Same Clincher, QD Clincher, or Straight Wall (Dunlop) Rim. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 28 x 3 | 29 x 3½ | Penna | Ajax | ......... | ...... | Michelin | ............ | Firestone |
| 30 x 3 | 31 x 3½ | Penna | Ajax | Shawmut | ...... | Michelin | ............ | Firestone |
| 32 x 3 | 33 x 3½ | Penna | .... | ......... | ...... | Michelin | ............ | ........ |
| 30 x 3½ | 31 x 4 | Penna | Ajax | Shawmut | ...... | Michelin | ............ | Firestone |
| 32 x 3½ | 33 x 4 | Penna | Ajax | Shawmut | Prince | Michelin | ............ | Firestone |
| 34 x 3½ | 35 x 4 | Penna | Ajax | Shawmut | Prince | Michelin | ............ | ........ |
| 36 x 3½ | 37 x 4 | Penna | .... | ......... | ...... | Michelin | ............ | ........ |
| 30 x 4 | 31 x 4½ | ...... | .... | Shawmut | ...... | ........ | ............ | ........ |
| 32 x 4 | 33 x 4½ | Penna | .... | Shawmut | ...... | ........ | ............ | ........ |
| 34 x 4 | 35 x 4½ | Penna | Ajax | Shawmut | Prince | ........ | Michelin QD | Firestone |
| 36 x 4 | 37 x 4½ | Penna | Ajax | ......... | Prince | ........ | Michelin QD | Firestone |
| 34 x 4½ | 35 x 5 | Penna | Ajax | ......... | ...... | Michelin | Michelin QD | Firestone |
| 36 x 4½ | 37 x 5 | Penna | Ajax | Shawmut | Prince | Michelin | Michelin QD | Firestone |
| 38 x 4½ | 39 x 5 | Penna | .... | Shawmut | Prince | ........ | ............ | ........ |
| 42 x 4½ | 43 x 5 | Penna | .... | ......... | ...... | ........ | ............ | ........ |
| 36 x 5 | 37 x 5½ | Penna | Ajax | ......... | ...... | ........ | ............ | Firestone |
| 36 x 5 | 38 x 6 | Penna | .... | Shawmut | Prince | ........ | ............ | ........ |
| 36 x 5½ | 37 x 6 | Penna | .... | ......... | ...... | ........ | ............ | ........ |
| 38 x 5½ | 39 x 6 | Penna | .... | ......... | ...... | ........ | ............ | ........ |

# TABLE II. OVERSIZE TIRES.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 28 x 3 | 29 x 3½ | ............ | Fisk Cl | ........ | ....... | ..... | Diamond | ........ | ...... |
| 30 x 3 | 31 x 3½ | ............ | Fisk Cl | ........ | ....... | Kelly- | Diamond | Lee PP* | Lee R* |
| 32 x 3 | 33 x 3½ | ............ | Fisk Cl | ........ | ....... | Kelly- | Diamond | ....... | ...... |
| 30 x 3½ | 31 x 4 | Firestone QD | Fisk Cl | Fisk QD, BO | Fisk SS | Kelly- | Diamond | Lee PP | Lee R |
| 32 x 3½ | 33 x 4 | Firestone QD, SS | Fisk Cl | Fisk QD, BO | Fisk SS | Kelly- | Diamond | Lee PP | Lee R |
| 34 x 3½ | 35 x 4 | Firestone QD, SS | Fisk Cl | Fisk QD | ....... | Kelly- | Diamond | Lee PP | Lee R |
| 36 x 3½ | 37 x 5 | Firestone QD | Fisk Cl | Fisk QD | ....... | ..... | Diamond | ........ | ...... |
| 30 x 4 | 31 x 4½ | ............ | | | | | | | |
| 32 x 4 | 33 x 4½ | ............ | ....... | ........ | ....... | Kelly- | Diamond | ....... | ...... |
| 34 x 4 | 35 x 4½ | Firestone QD | Fisk Cl | Fisk QD | Fisk SS | Kelly- | Diamond | Lee PP | Lee R |
| 36 x 4 | 37 x 4½ | Firestone QD | Fisk Cl | Fisk QD | Fisk SS | Kelly- | Diamond | Lee PP | Lee R |
| 40 x 4 | 41 x 4½ | ............ | Fisk Cl | Fisk QD | ....... | ..... | | | |
| 32 x 4½ | 33 x 5 | Firestone QD | | | | | | | |
| 34 x 4½ | 35 x 5 | Firestone QD | Fisk Cl | Fisk QD | ....... | Kelly- | Diamond | Lee PP | Lee R |
| 36 x 4½ | 37 x 5 | ............ | Fisk Cl | Fisk QD, BO | Fisk SS | Kelly- | Diamond | Lee PP | Lee R |
| 38 x 4½ | 39 x 5 | Firestone QD | ....... | Fisk QD | ....... | Kelly- | Diamond | ....... | ...... |
| 40 x 4½ | 41 x 5 | ............ | ....... | Fisk QD | ....... | ..... | Diamond | ........ | ...... |
| 42 x 4½ | 43 x 5 | Firestone QD | Fisk Cl | Fisk QD | ....... | ..... | Diamond | ........ | ...... |
| 36 x 5 | 37 x 5½ | Firestone QD | ....... | ........ | ....... | Kelly- | Diamond | Lee PP | Lee R |
| 36 x 5 | 38 x 6 | ............ | ....... | Fisk QD | ....... | ..... | | | |
| 36 x 5½ | 37 x 6 | ............ | | | | | Diamond | ........ | ...... |
| 38 x 5½ | 39 x 6 | Firestone QD | ....... | ........ | ....... | Kelly- | Diamond | ....... | ...... |
| 34 x 4½ | 36 x 5½ | ............ | ....... | Fisk QD, BO | ....... | ..... | Diamond | ........ | ...... |
| 36 x 4½ | 38 x 5½ | ............ | ....... | Fisk BO | ....... | ..... | | | |

# TABLE III. OVERSIZE TIRES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 28 x 3 | 29 x 3½ | Goodrich Cl | Goodrich QD | ........... | Knight | Walpole | Imperial Cl, QD, SS |
| 30 x 3 | 31 x 3½ | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 32 x 3 | 33 x 3½ | Goodrich Cl | Goodrich QD | ........... | Knight | Walpole | .................. |
| 30 x 3½ | 31 x 4 | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 32 x 3½ | 33 x 4 | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 34 x 3½ | 35 x 4 | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 36 x 3½ | 37 x 4 | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 32 x 4 | 33 x 4½ | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 34 x 4 | 35 x 4½ | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | .................. |
| 36 x 4 | 37 x 4½ | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 40 x 4 | 41 x 4½ | Goodrich Cl | ........... | ........... | ...... | ....... | .................. |
| 34 x 4½ | 35 x 5 | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 36 x 4½ | 37 x 5 | Goodrich Cl | Goodrich QD | Goodrich SS | Knight | Walpole | Imperial Cl, QD, SS |
| 38 x 4½ | 39 x 5 | ........... | Goodrich QD | ........... | Knight | Walpole | .................. |
| 40 x 4½ | 41 x 5 | ........... | Goodrich QD | ........... | ...... | Walpole | .................. |
| 42 x 4½ | 43 x 5 | Goodrich Cl | Goodrich QD | ........... | Knight | Walpole | .................. |
| 36 x 5 | 37 x 5½ | Goodrich Cl | Goodrich QD | ........... | Knight | ....... | .................. |
| 36 x 3½ | 37 x 6 | ........... | Goodrich QD | ........... | ...... | Walpole | .................. |
| 38 x 5½ | 39 x 6 | ........... | Goodrich QD | ........... | ...... | Walpole | .................. |
| 42 x 4 | 43 x 4½ | ........... | Goodrich QD | ........... | ...... | ....... | .................. |
| 40 x 5½ | 41 x 6 | ........... | Goodrich QD | ........... | ...... | Walpole | .................. |
| 42 x 4½ | 44 x 5 | ........... | ............ | ........... | Knight | ....... | .................. |

R—Regular.
* PP—Punctureproof.

# Operating and Caring for the Motor Car

## How the Various Parts of the Modern Automobile Work and How Their More Common Troubles are Remedied Explained in Simple Language

By

Morris A. Hall, M.E.

*Member Society of Automobile Engineers*
*Member American Society of Mechanical Engineers*

CHAPTER I.

**DRIVING**

The automobile is the first thing to be learned, its operation in a manner which will be safe for both the operator and the public being of prime importance, even more, perhaps, than a clear understanding of the principles upon which the various parts work. The latter

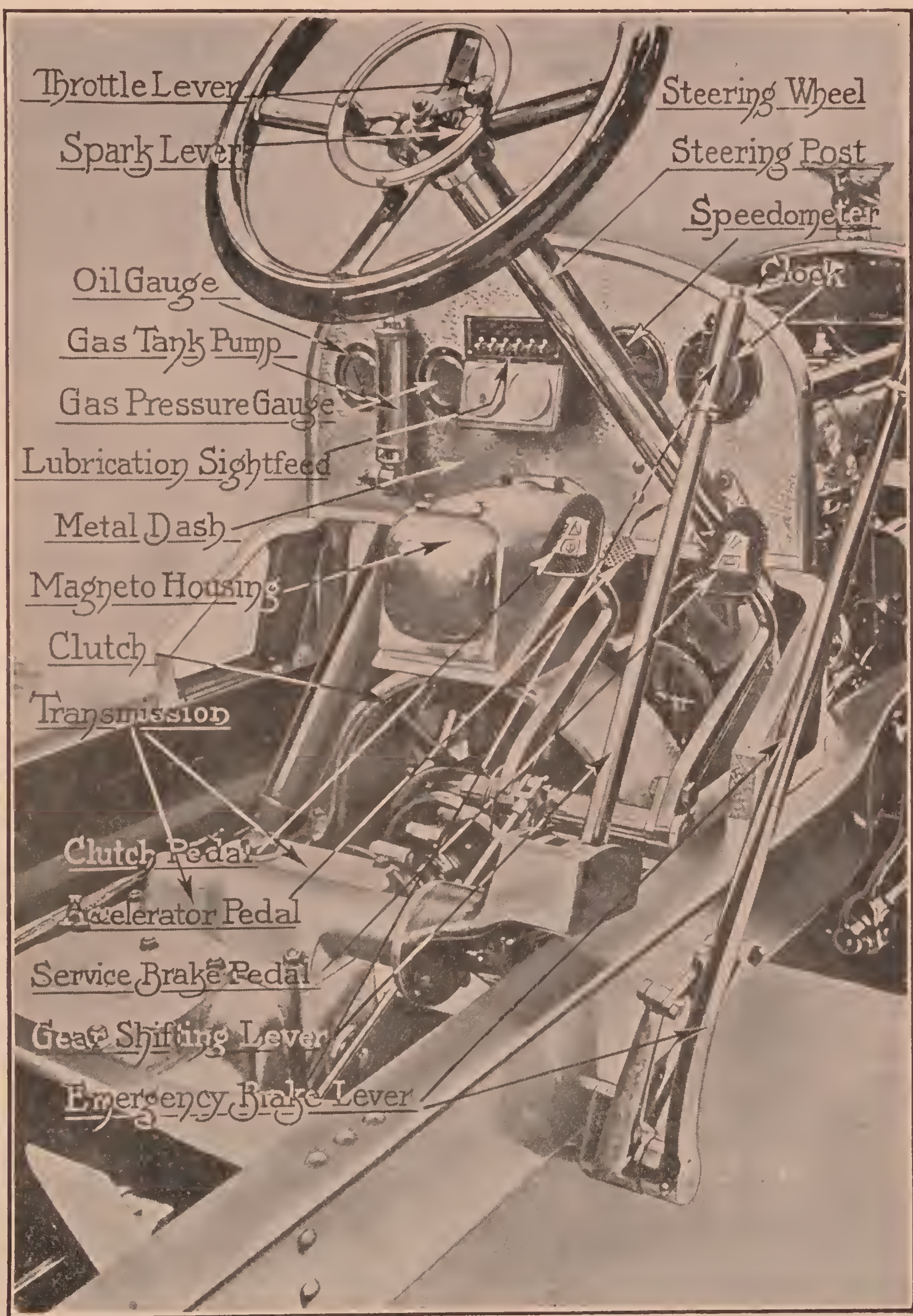


Fig. 1—View of the controlling mechanism of a modern car from the rear, showing what the novice driver must master.

should not be minimized at all, and every owner and driver of a motor car should make it a point to learn how every part works and why it works that way. Otherwsie, he will be completely at sea when trouble comes.

Driving is easily and quickly learned, but should be taken up in a systematic and regular manner, in order to learn it right. There are eight things which must be operated in driving the car, some of which require to be operated two and three at a time. For this reason, it is important to learn to operate them right in the first place, and to know what result should be expected when they are so operated.

These eight items, in the order in which they should be mastered, are:

1—Steering.
2—Operation of foot brakes.
3—Operation of hand brakes.
4—Operation of clutch.
5—Control of the engine by means of the throttle lever.
6—Control of the engine by means of the spark lever.
7—Horn or warning signal.
8—Changing speeds.

Second only to these, and of equal importance to the operator of the machine, are what might be called the daily needs of the machine, the attention to the little things without which it will not operate or will operate in a poor, faulty, or dangerous manner. These should be considered in detail by the novice driver, even before he can drive well, for if they be not taken care of, driving may become out of the question or impossible.

A good way in which to remember these little matters which must be attended to before it is certain that the motor and other parts of the car will start and operate properly during the whole trip is to compose some little word which will give the clue to all these matters. As a suggestion, the writer offers the two words WANTS and GOT. The driver can remember these well enough if he will ask himself the very natural questions: What do I WANT? and Have I GOT everything? These two words stand for the following necessities:

W—ater
A—cetylene or Lamps
N—uts & bolts
T—ire pressure
S—park retarded.

G—asoline
O—il
T—esting brakes and similar important parts

To explain these briefly, Water would represent the inquiry: Does the water system need any attention, or is it fully filled? This might include as well the query: Is the pump working properly? etc. Acetylene would stand for the questions: Have the lamps been attended to? Kerosene form filled with oil? Is gas tank charged enough to see us through the night? and the other natural questions about the lighting system.

Many nuts and bolts come loose or shake off, and it is possible to lose any important or valuable part as well as cripple the car by neglecting these little things. For that reason, it is well to go over all the important and handy nuts and bolts before starting out. The majority of tires are not inflated enough, but if the tires have been pumped up lately and are found soft, it is a sign of leakage somewhere. All tires and tire-repair material should be made sure of before starting.

### How to Remedy the Most Common Automobile Troubles

**1. When the motor heats very quickly.** The radiator may be empty or the water supply very low.

**2. When the cooling system has been filled properly but the motor still heats up quickly.** The water connections may be leaking badly, particularly where rubber hose joins metal pipes together. Or the pet cock at the bottom of the system may have been opened accidentally.

**3. When the cooling system is absolutely all right throughout, but the engine heats very quickly.** The spark may be advanced too far or retarded too far, both which cause overheating under some circumstances.

**4. When cooling system is all right throughout and the spark is set correctly for its running speed, but the engine still heats very quickly.** The lubricant may be too low, so that the cylinders have become dry. This may be caused by an obstruction in the oil feed pipes, shearing off of a pin in the oil pump drive as much as by a lack of oil.

**5. How hot should the cooling system get, running properly?** On long runs, it may very properly get so warm that a person can just touch the radiator with the bare hand but cannot hold it there without getting burned. On very heavy work, such as very long hills, shorter ones taken at a very fast speed, heavy pulling through deep sand, mud or stones, or under any circumstances under which the motor must run very fast or pull very hard for a long time it may get so hot that a person cannot even touch the radiator without getting burned. But

Unless the spark is retarded, before trying to crank on a car which is not fitted with a self-starter, the operator is liable to break his arm or wrist, or do some injury to himself otherwise. Always retard the spark as far as it will go in stopping, then it will be ready for starting the next time—that is, it will have to be moved deliberately before the driver can injure himself through a backfire while cranking.

Of course, gasoline is important; no machine will run without fuel, and every driver should actually look into the tank before starting out, no matter how much fuel he may *think* is in it. Oil is of equal or greater importance, and the driver should know for a certainty that the lubricator or crankcase is filled, as the case may be, and that a supply may be obtained on the route, or else that an extra supply is carried on the car.

Unless the brakes work well and respond quickly, they will be useless to the operator, and while he is still in the novice class he should try them out before starting on any kind of a long trip or one in which any steep hills are to be encountered.

Each one of these items will be taken care of later on, in its proper place, and considered in more detail, so what has been said will suffice for the present. To return to the eight most important items in car operation, the first of these is steering.

**STEERING** comes first, because unless the driver be skilled in handling the *steering wheel,* he is running great danger, as well as jeopardizing others. It is very easy to turn the wheel a trifle too far and thus steer the car into another coming along, or to turn it too little and strike a curb or tree. In general, steering wheels are from 14 to 18 or more inches in diameter, with an oval cross section about 1 inch thick by 1½ to 2 inches wide. This is a convenient size for the hand to grasp. To facilitate grasping the wheel readily, many firms make the surface rough in one manner or another, as deep grooves cut around its surface, notches on the inside, the use of a rough-surfaced material, etc.

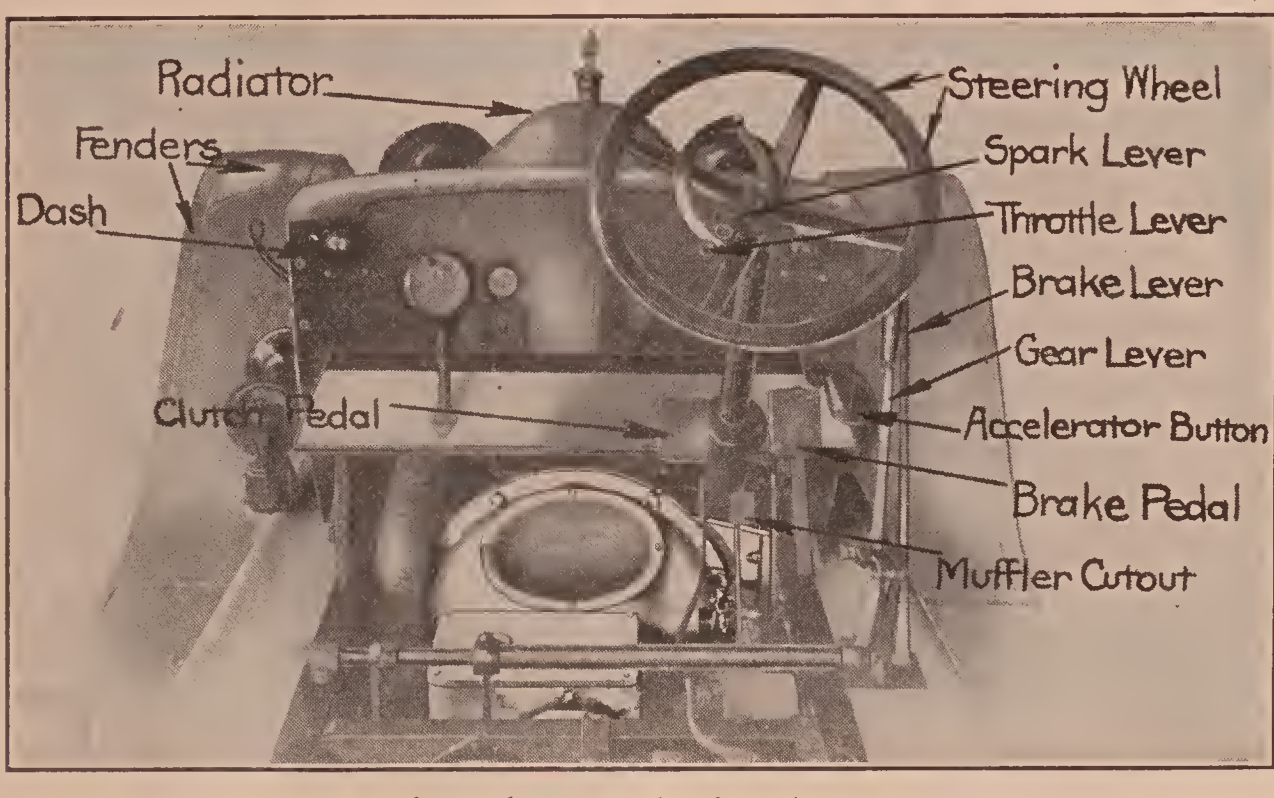


Fig. 2—Another car seen from the rear, showing the control parts with the dashboard in place. Two additional control parts will be noted over Fig. 1.

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unless the water is very low, or unless the car is running through the mountains, it should never get so hot that steam will be seen coming from the radiator.

6. **When the engine backfires at starting.** The spark has not been retarded, or, if so, not enough.

7. **Spark lever has been retarded, but motor still backfires regularly at every turn.** The rod connections between the spark lever and the magneto may have become disconnected or broken.

8. **Spark lever and connections are correct, but motor will not start.** If a spark is obtained in each and every cylinder, the gas must be at fault. See if the tank contains any fuel.

9. Spark is correct throughout and tank has **sufficient gasoline, but engine will not start.** The fuel may be shut off, or, if not, the outlet side of the tank may be so low that the fuel will not flow to the carburetor.

10. **What is the remedy for this?** If more fuel is available, fill the tank; if not, push the car along on the road, so that the side which is too low becomes high enough to start the fuel flowing. Then start the engine, and in driving to the nearest fuel supply station, keep the low side of the car upon the high part of the road. Sometimes, trouble of this kind may be remedied by bending the copper pipe from the gas tank to the carburetor in such a way as to take out the low spots and make a more nearly straight line from tank outlet to carburetor. If the outlet is on one side and the carburetor on the other, it may

The steering wheel is attached to the *steering post* by means of three, four or six arms of metal, four being generally used. The operator should not try to turn the wheel by means of these, but should use the rim, grasp it at the two sides with the thumbs above and all the fingers below and wrapped around it. This is much the same way in which a baseball bat is held, except that instead of one hand being alongside or above the other in a parallel line, the two are spread apart the diameter of the wheel. In turning the wheel, the hand on the side toward which the car is to be turned should have a firm grip on the surface until the turn is completed. If desired, the other hand need not grasp it so tightly and turn with it, but can be opened slightly and the wheel allowed to slide through its fingers.

The elbows should be held in close to the side, and if the wheel is not too large nor too small, the forearms will come straight forward from the body in parallel lines. This position is most comfortable, while the elbows against the sides of the body give a firm brace against any road shock which is transmitted back through the steering gear. With the fingers below the wheel and wrapped around it as outlined above, the operation of spark and throttle levers will be most simply and easily accomplished. This will be explained later.

Both of the views of cars which have been shown thus far present right-hand control with right-hand levers—that is, the steering post was located on the right-hand side of the chassis, with the levers on the same side when they would be operated by means of the right hand only. In order not to confuse the driver, no other forms will be shown at this time, although it should be stated that the present tendency is toward the location of the steering post on the left side instead of the right, as shown, in which position right-hand levers come in the center of the chassis. This is designated as left-side control with central levers, and, as will be explained later, is the ultimate outgrowth of the original right-control right-lever form on the one hand, and the left-control left lever's first departure from it.

While it has been pointed out above how steering is done, it has not been explained in detail as to just what happens. This will be useful because, knowing what parts must move or turn, the driver can use more care in protecting, oiling, or otherwise taking care of those particular ones. Fig. 4 will point out the parts in detail and the functions of each, without any others to distract the attention. In this, the steering wheel is marked *A*. It is shown with four arms *B*, and is attached to the upper end of the steering post *C*. The latter terminates at its lower end in a housing *D*, which encloses the worm and gear used to turn the rotary motion in a vertical plane into similar motion in a horizontal plane. The worm is fixed to the steering post shaft while the gear is fastened to the steering arm *E*. A rotation of the wheel *A* turns the former, which in turn rotates the latter, this giving a partial swing to the arm *E*. To the lower end *F* of the last named, which moves in a back-and-forth line, is attached the steering link or steering rod *G*. This is fastened to the end *I* of the steering arm *M* of the right-hand knuckle *J* by the universal connection *H*. It should be explained that a universal connection is one which will allow of motion in any direction or any plane. Usually this is brought about by a ball and socket joint, as in this case, the end of

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be possible to turn the tank end for end without emptying it.

**11. If fuel system is all right throughout and gasoline is flowing to the carburetor, while sparking system appears to be right, but engine still will not start.** Examine the spark plugs; one may have been screwed out and forgotten, or one may be broken. Many owners lock their cars by unscrewing a spark plug, but forget this when they start again, and then wonder what the trouble is. Porcelain plugs break more easily than mica. This trouble may be noted in a moment by taking hold of the tops of the plugs, one at a time; if broken, it will be possible to move the top, otherwise not.

**12. Engine starts properly and runs very well, but when clutch is thrown out, gear engaged, and then clutch let in again, the car will not start and the engine stops.** The driver has forgotten to take off the emergency brake, which holds the car and stalls the engine.

**13. Engine starts properly, brake is off, clutch seems O. K., but when gear is engaged and clutch let in engine runs fast and car does not move.** The gear may not have engaged, or, if so, slipped out again when the power was applied. Many times on a rough road, particularly when in high gear, with an old car, the car will suddenly come to a standstill and the engine will race. The trouble is that the gear has shaken out of mesh, worn pins in the lever and rod connections, allowing this.

**14. Everything seems O.K., but on ascending a slight grade the car begins to surge forward, lose ground, then surge forward again, con-**

*I* being the ball and within the casing *H,* the socket and an adjustment for taking up wear.

Now the arm *M* has a fork shape, the other part *P* having a ball end *O* as well. This is enclosed in a socket (with an adjustment) on the right-hand end of the cross rod to the other knuckle, where it is fastened by means of the other ball and socket joint *Q*. When the wheel is turned to the left as the small arrow shows, the worm turns with it to the left. This rotates the worm gear toward the driver, and with it the lever *E* and the rod *G*. This pulls back the lever arm *M,* and moves the knuckle *J* about its center line *K-L*. The result is the outer end with its bearings *Z-Z,* is moved forward, as the arrow shows. At the same time, the arm *P* with its ball joint *O* is moved to the right, drawing the other end *Q* with it. The latter movement moves the left-hand knuckle about its center line, pulling it backward, as the arrow indicates.

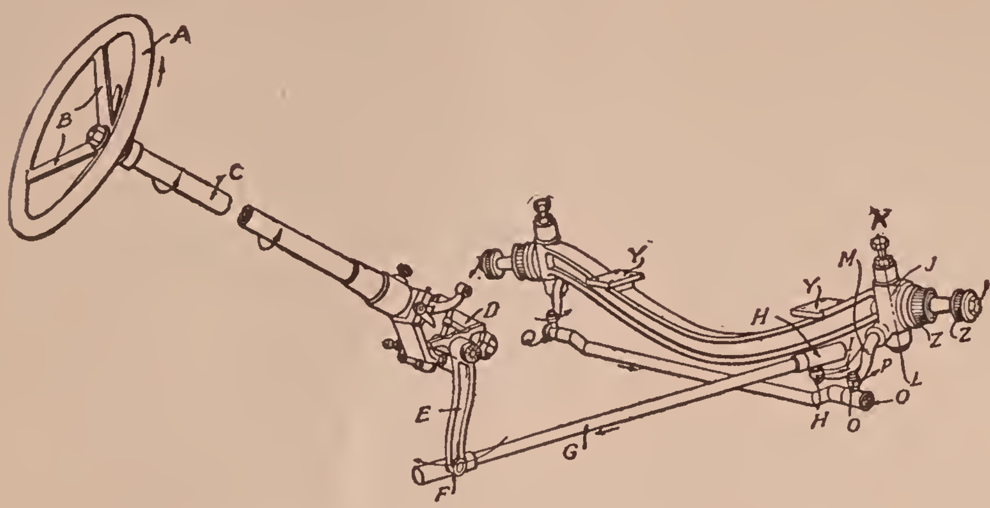

Fig. 3—Steering gear of the Pierce-Arrow car, showing how this is connected with the front axle and how the various parts work.

A moment's consideration of this will show that the movement of the right-hand axle end forward means that the right-hand wheel is turned in or to the left, while moving the left-hand axle end backward turns the left-hand wheel out or to the left. Thus both wheels are turned to the left together, and referring back to the motion of the hand wheel, by a turn of that to the left. This is as it should be; a turn of the wheel to the left produces a movement of the automobile in that direction, while a turn to the right moves the car in that direction.

To those who have had previous experience with motorboats, this is a little bit confusing at first, for the movement of a boat is just the opposite of its tiller. There a turn to the left steers the boat to the right, while a turn to the right heads the boat to the left.

From what has been said, it is apparent that there are eight points in the steering system which require constant attention and lubrication. These are: (1) The bearing of the steering shaft within the post; (2) the worm and gear; (3 and 4) the ball and socket joints at each end of the steering rod *G;* (5 and 6) at both ends of the connecting link *O* to *Q,* and (7 and 8) the two steering knuckles. A safe rule for lubrication is to oil 1 monthly and 3 to 6 weekly, and grease 2 monthly and 7 and 8 weekly. The adjustments at 3, 4, 5 and 6 should have attention every second month, while once a year is often enough for the steering gear and knuckles.

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**USING THE BRAKES** is, next to steering, the most important item for the novice to learn. Granting that the car has been started by some one else and is in good running order, it will continue to run in the hands of the novice until it be stopped. This may be accomplished in either one of two ways: Using the *brakes,* or stopping the *motor.*

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**tinuing this even when the top of the hill has been reached and the down grade started.** The fuel tank is almost empty, but the side movements of the car allow a little of what gasoline is left to splash through to the carburetor each time there is such a movement. This started when climbing the hill, but continued after the crest was passed. Remedy: More fuel, or open the reserve-tank connection.

**15. When the steering wheel turns for part of a turn without turning the front wheels.** The wheel is loose on the steering post and should be fitted with a new key, one that fits more tightly.

**16. When the turning of the steering wheel operates but one front wheel in a similar manner.** The cross rod or tie rod, which should connect the two steering knuckles, is broken or has parted or become loose.

**17. When the steering wheel turns part of a turn without turning the front wheels as in No. 1 but the hand wheel is not loose.** In this case, the worm and sector which comprise the mechanism of the steering gear

Practically all cars, nowadays, have two complete and separate sets of brakes, both located on the *rear wheels*. One is operated by the right-hand *foot pedal,* and is called the *service* or *running brake*. It is also referred to frequently as the foot brake on account of its method of operation by the right foot. When the novice operator sees danger ahead or what appears to him like danger, the first thing to do—and it must be done as quickly as possible—is to stop the car. The danger being in front of him, he, approaching it rapidly, involuntarily throws forward feet and hands to protect himself. This involuntary movement is useful in that it serves to operate the foot brake, the forward movement of the right foot applying this set to the rear wheels, and checking the forward movement of the car.

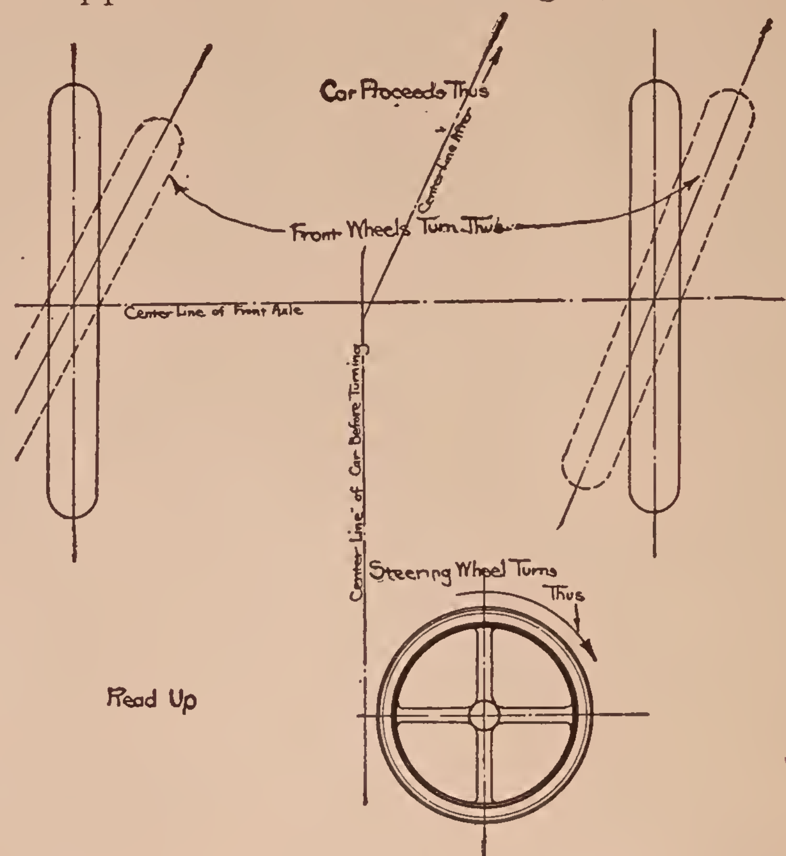

Fig. 4—Diagram showing how the automobile turns in the direction in which the steering wheel is turned.

The second set of brakes is called the *emergency brake,* or, because of its method of operation by the outside *hand lever,* the *hand brake*. This set is located on the rear wheels also, and generally is larger and more powerful. The longer hand lever (as compared with a short foot pedal) gives a greater leverage, and the driver can exert great force on this set. In fact, a good test of the size of a car's emergency brakes is the ability to hold the wheels from operating against half the power of the motor.

When the operator notes that even with the foot brake applied the car continues to approach the danger, his second movement is to draw back away from it. This is useful also, in that the emergency brake lever is set by drawing it backward. This lever carries a *ratchet* at its lower end, so that whatever movement is given to the brake lever by the hand is retained automatically, until the driver releases the *catch* and lets it go of his own free will. This is extremely useful in that the brake may be applied as far as it will go apparently, and then if the car continues to move forward, with the energy of desperation the driver may grasp the handle again and pull it toward him a couple more notches.

When this lever has been put on for a certain distance and amount, as predetermined by the manufacturer of the car, it throws out of connection the *engine* and the wheels, so that the power of the former is no longer applied to driving the car, and the brakes must absorb only the momentum of the moving car, due to its weight and speed.

The two sketches herewith, Fig. 5, showing the service brakes, and Fig. 6, showing the emergency set, present the operation of these very important members in a more graphic and convincing manner, indicating at the same time the

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must be replaced as they show signs of serious wear.

**18. When there is no lost movement or back lash but the steering is uneven and jerky.** One of the rods must be bent or the various parts need lubrication, or both.

**19. The steering wheel shakes with movement of the car, sometimes very badly, enough to tire the arms in a short drive.** It is not well attached to the dash and frame. If there is no place for additional fastenings, have a new brace made which will hold it tightly. This may run from the steering post to the side frame, just back of the dash.

**20. The ball joint end is loose in its socket.** To give a universal movement, the ball joint is necessary. If this wears down badly on two sides so as to make it flat there, it may fall out of the elongated hole in which it is supposed to work. Remedy: A new ball end. Temporary remedy: A leather boot which will hold it in place and provide good lubrication at all times.

**21. Steering troubles caused by worn front axle bearings.** These may be detected by jacking up the front wheels clear of the ground, then rocking one of them, using both hands. If it will rock, there is wear, and this calls for renewed or new bearings.

**22. After hitting a low obstruction in the road the front wheels toe in and will not respond to the steering gear.** The front tie rod or cross connecting rod has been bent backward, thus pulling the wheels in toward one another. Remedy: Straighten the rod as much as possible under the car, so as to free the ends from binding, then take it off and finish the straightening process.

components of the system, so that it makes caring for them more simple. Referring to Fig. 5, it will be noted that this moves forward in the arc of a circle

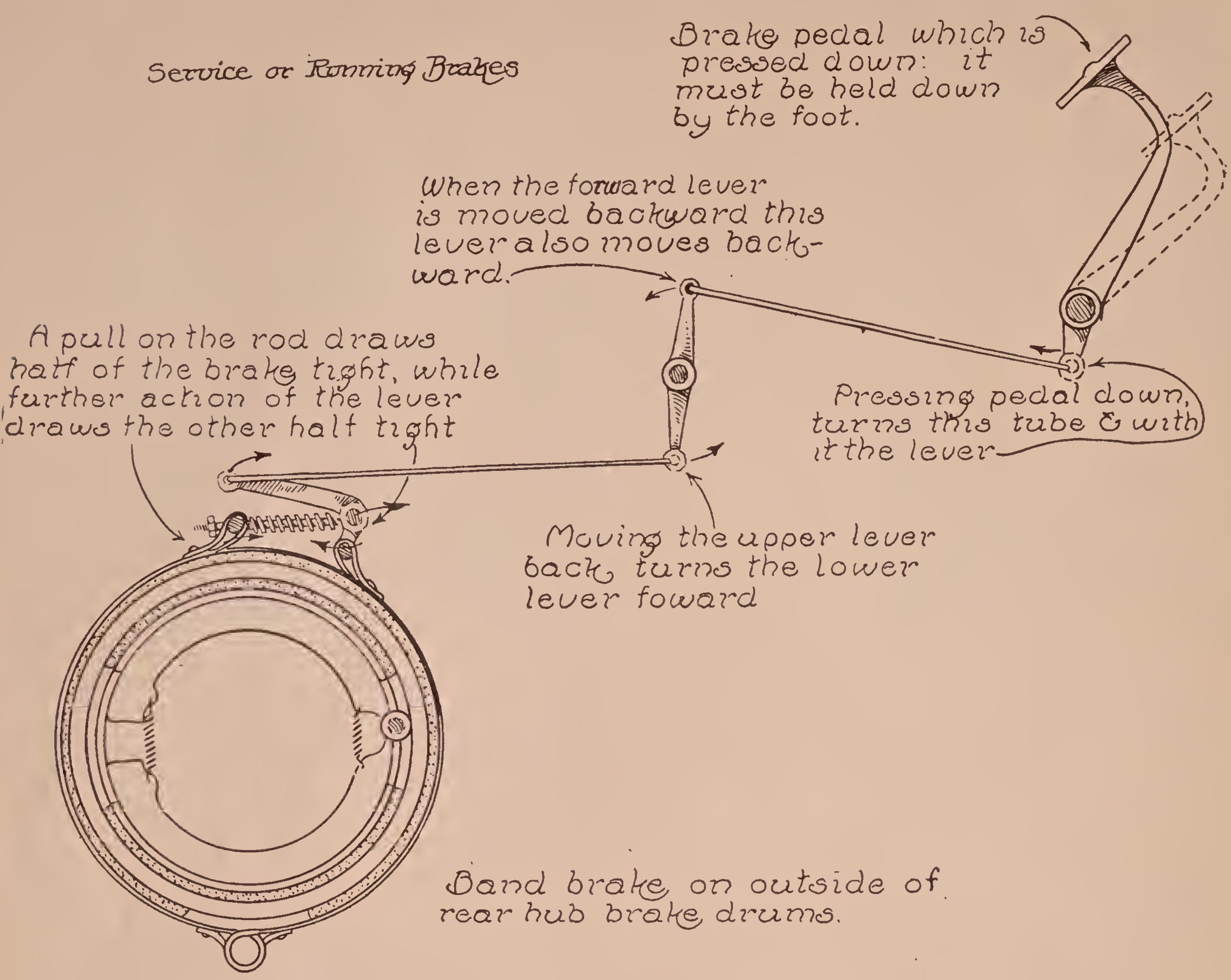


Fig. 5—Diagram showing the action of the usual form of service or running brakes.

as depressed by the foot. It is attached to a cross shaft, or tube, so that the latter moves when it moves. There is also attached to this member what might be called the first lever for the lack of a better name. This being attached to the tube or shaft must move with it; it is connected by means of an almost horizontal rod of small diameter to what we may call the second lever, which is thus forced to move when the first lever moves and in the same direction.

This is attached to a second tube, somewhere near the middle. At the ends of this, close to the frame as possible, are fixed a pair of short levers, which we will call the third levers. Each one of these has a rod running from it to the actual brake lever on its side. Thus the operation of the third levers applies the band brakes, more or less, according to the force with which it is moved. As the second lever actuates both of these, and is in turn forced to move by the

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**23. After hitting an obstruction in the road, the wheels toe out badly but at different angles, and only one will respond to the steering gear.** The front tie rod has pulled apart where it was welded or brazed. Take it off and have the end rewelded or rebrazed in place, being careful to get the length just right.

**24. When steering becomes erratic and wheels turn from one side of the road to the other without apparent cause.** The front axle is doubtless badly bent and the erratic actions when steering will continue until the bend is found and straightened.

**25. When brake lever is applied, the brakes grip but later slip.** Surface of the brake lining is either slippery from grease or oil, or else is worn through, so the metal rivets take hold at first and then slip. In the first case, clean brake lining with kerosene, then water, then dry. In the second, use new lining.

**26. When brake lever is applied, no result for some time, then, with more pressure, brakes begin to take hold.** Poor adjustment, not tight enough, and probable lost motion in the brake operating rods and levers. Try each joint or connection for wear, then readjust brake to a smaller diameter.

**27. When brakes are applied car slews around to one side, the same as when skidding.** The brakes are not equalized properly, and one is taking hold before the other begins to act. Readjust the equalizing device.

**28. Both brakes take hold when applied, but do not stop the car.** Brakes are either too small for the car or poorly adjusted. Adjust to take hold more tightly.

movements of the first lever which are produced by the pressure of the toe on the brake pedal, it may be seen how a movement of the right foot checks the whole vehicle.

This system has nothing to hold the brakes on when they are applied, for which reason the extent of their application is governed by the amount of pressure applied originally by the foot and the length of time it is kept on. To hold the car more or less permanently by means of this brake, it becomes necessary to exert pressure upon its pedal for that length of time. This is not convenient, nor, generally speaking, is the service brake used in this manner. It is used for a short and more or less temporary check upon the vehicle's speed while running, as for instance when approaching a narrow but deep hole across the road. Then the vehicle would be checked quickly so that the occupants of the car would not suffer a severe bump such as would be the case in passing over this hole at speed.

Referring next to Fig. 6, this outlines in a similar manner the components of the emergency brake system. The operating member of this is the hand lever at the side of the car, usually but not always alongside the gear shifting lever and

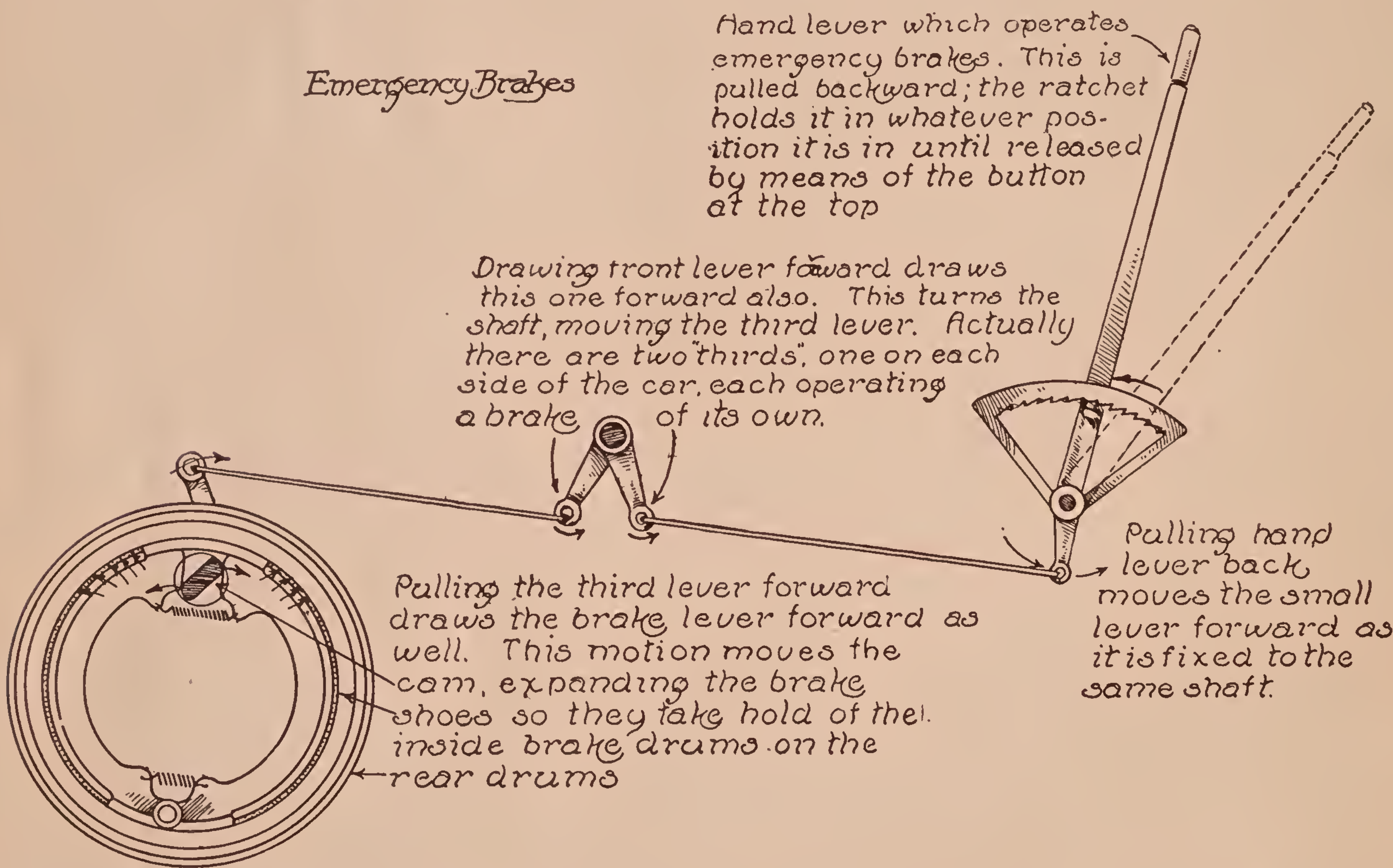


Fig. 6—Sketch indicating the components and method of operating the usual form of emergency brake.

operating on the same shaft or tube as an axis. This may be made to push forward, which was quite general in the early days, or pull backward, which is nearly universal now. The latter form is shown in the sketch.

This lever is provided with a ratchet so that when the lever is drawn back the latter slips over notch after notch and will hold the lever and with it the

**29. When emergency brake is applied and, after releasing same, the car will not start.** Brake spring, which returns brake system to the "off" position, is too weak and must be renewed.

**30. When service brake cannot be applied gradually, but refuses to take hold, then grabs hold.** A combination of poor adjustment with worn brake lining. New lining and a proper adjustment will fix this.

**31. When brake rods rattle and make a great deal of noise.** They pass over a frame member somewhere just at a point where there is considerable length to whip up and down. Wrap with tape or rags.

**32. When there is considerable give in the brake system, which always takes hold, however.** This indicates considerable wear in the various pin connections. If serious, it means new pins. Possibly new rod ends, also.

**33. When clutch pedal is let in, the clutch does not take hold.** Slipping. Remedy: Clean surface of leather or lining with kerosene, then wash and dry. Apply with a powdered chalk, or glass powder.

**34. When pedal is let in, clutch takes hold too quickly.** Fierce clutch. Remedy: Readjust spring to give less tension, also look over operating rods and pins for wear.

**35. Clutch will not engage readily when out or disengage when once in.** Sticks, due to lack of lubricant. Also possible if of cone type, that the edge of the leather has worn to a shoulder larger in diameter than female part. Remedy for this: New lining.

complete braking system which it controls, in any position in which it is left. More than simply holding it for a short time, it will retain the whole system as left for an indefinite length of time. Attached to the tube or shaft which forms the axis of this lever's movement is what will be called the first lever (as in the case of the running brake system). This moves with the hand lever, its direction and amount of movement depending upon the manner in which it is placed and its size. As sketched out, a backward movement of the hand lever will produce a forward motion of the first lever. This is connected to the second by means of a rod, through which the latter will be pulled forward.

This second lever in turn is attached to a tube, near the ends of which are a pair of third levers. Consequently movement of the second produces similar motion of the third levers. The two latter have each a rod connecting it with the lever on the expanding brakes which work within the brake drums on the rear wheels. The movement of this lever turns a cam which spreads apart the two halves of the brake. Spreading these pushes them against the surfaces of the brake drum all around, so that this lever motion applies the brakes and retards the movement of the car. The action of the hand, then, in pulling the brake lever backward ultimately turns the cam and thus applies the brakes.

It will be noted that the length of this hand lever is considerable and that as compared with the first lever it is perhaps five or six times as long. This is the amount of leverage which this lever combination gives the driver, so that any pull which he applies is multiplied in this ratio. As levers one and two are of approximately equal size, none of this gain in leverage is lost there; similarly with lever three and the brake lever. The latter, however, as compared with the lever arm of the cam, has an advantage again of five or six to one, so that the total advantage of the driver becomes about 25 or 36 to 1—that is, for every pound pull which he can apply to the brake handle, from 25 to 36 pounds is actually applied to the two surfaces of the brake upon which the cam operates. It is by this multiplication of effort that a comparatively small and weak man can overcome the power of the engine amounting to from 25 horsepower upward.

Generally speaking, the emergency brake is considered the most important, and as the internal expanding form is thought to be stronger, more certain in its action, and less liable to wear out of adjustment, this type usually is used for the emergency. The simpler and cheaper band form is used for the service brake, as the constant use of the latter requires frequent relining, which necessitates a simple and easily accessible form.

Again, it is easier to apply great force with the hand, particularly as the design will usually give greater leverage to a hand lever than a pedal. For this reason it is almost universal to make the hand-operated brake the emergency and the foot-operated form the running brake. There are, however, many instances, notably on motor trucks, where this situation is reversed and the emergency brakes are put on the pedal and the service brakes on the hand lever.

As stated previously, the emergency is connected usually with the engine in such a way that at the limit of its motion—that is, when it is put on as hard as

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**36. Switching off either spark or throttle has no effect on operation of motor.** Pin has dropped out of rod connection so that it really does not shut off, the lever and rod moving without moving the throttle or contact points.

**37. Opening and closing the throttle lever does not affect the action of the engine.** The rod is either too loose, has a worn connection, or is broken.

**38. Movement in one direction, as opening throttle, gives results; but in the opposite direction, as closing, does not.** One of the holes at a rod connection has become worn and is very long. This lets the pin pull the rod in one direction but not in the other until this wear is taken up.

**39. With all connections intact, shutting off the throttle does not stop the engine's running.** There is a leak past the throttle valve, or else a previous owner has bored a hole in it to get this result.

**40. When spark lever is shut off, but motor continued to run and gets an explosion in each cylinder each time.** Red-hot parts in the interior of the cylinders are igniting the charge. These should be removed, as they will cause preignition and other troubles.

**41. Squeezing the bulb of the hand-operated horn brings forth no sound.** The reed inside the horn has spread so widely that the air passing through will not cause it to vibrate. Take horn apart, and slide nail between reed and tube, then bend over. This will straighten the reed and horn will operate correctly.

**42. Pressing the button of an electric horn does not bring forth a sound.** The batteries have run down, or, if storage, are exhausted.

can be, it disconnects the motor from the driving mechanism. This device is called the clutch, and it forms a flexible means of connecting engine to transmission so that the two may be disconnected at will, this being necessary frequently when changing gears. Another need for a disconnecting means is at starting. The gasoline engine cannot start under a load, but must be started alone and then the load applied to it gradually as it gains speed and power.

By interconnecting the emergency brake lever and this disconnecting means, it is certain that the driver will not be exerting his whole force to stop the car while the engine is continuing to drive it as before. Thus in an emergency which required instant stoppage the driver might forget about the engine and bend all of his energies to applying the brakes. If the power was still applied, undiminished, this effort would go for nothing and the car would continue to advance despite the desperate application of the brakes. To make such a system impossible, the extreme throw of the emergency brake, such as would be used only in the worst or most strenuous cases, applies this disconnecting means and automatically throws the engine out of connection.

Another method of interconnection which has been used somewhat extensively since the craze for simplification set in is that in which the service brake is connected up to the clutch pedal in such a way that the first motion of throwing out the clutch does not apply the brake, but a further movement of the pedal in order to throw the clutch out completely throws on the brake. This is done on the assumption that when the clutch is thrown clear out, out to the limit, there is some need for brakes. When this arrangement is used, it is the general plan to do away entirely with the lever for the emergency brake, and put it on the other pedal which ordinarily applies the service brake. With this arrangement of the control system, when the driver wishes to stop very suddenly, he applies both pedals with all his strength.

**THE CLUTCH** is the name of this disconnecting means, and it may be thrown out of or into operation at the will of the driver. Normally, a heavy *spring* holds it in engagement, the driver throwing it out by pressing the left-foot pedal forward. This pedal is called the *clutch pedal* for that reason. Whenever it is held forward at its extreme position, the engine will run idly and will not be driving the car. When it is released partly, but is still held forward a little bit, the engine will be exerting a little power but not all, only sufficient to give the wheels a partial turn now and then. This is called *slipping* the clutch, and is extremely useful when the new driver finds himself in a tight place and does not know what to do.

Then he may apply the left-foot pedal, slip the clutch somewhat and at the same time apply the right-foot pedal, thus putting on the running or service brakes. The former disconnects the engine, and the latter checks the car. This slows the vehicle down or brings it to a standstill, according to the force with which the two are applied. The car may then stand still, with the engine running as before, not driving the car, but ready to do so at any moment, until the danger is past or until the situation ahead becomes perfectly clear or sufficiently clear to give the driver confidence enough to go ahead anyhow.

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In the case of a rotary current generator supplying electricity, this can only be caused by a loose terminal, broken wire, or short circuit.

**43. Pressing the button of an electric horn gives forth a varying and uncertain sound.** The armature needs adjustment. In some horns, this may be moved toward or away from the diaphragm to increase or decrease the shrillness of the sound.

**44. In a bulb horn, pressure squeezes the bulb together, but it will not fill out again.** Either the rubber of the bulb is worn out and should be renewed, or else the air hole through the reed is clogged so that air cannot pass through it to the bulb interior. If the latter, the sound made by the horn will be very weak, squeaky, and not at all penetrating or far-reaching.

**45. In changing from low speed to second, engine slows down.** As load is added to the engine, it must be speeded up or given more gas to produce more power for this extra load. Remedy: Open the throttle a couple of notches before changing.

**46. In changing from second to high, the engine slows down very much and almost stops.** It should have been given more gas before making the gear change. Remedy: Throw out the clutch, let the motor speed up, and then give it more gas before throwing in the clutch again.

**47. In changing down from high to second, the engine slows down and seems to hesitate, then picks up again.** The mixture is too rich, and when the throttle was opened wide for high speed and the gear lever moved into second, the amount of gas was not cut

CHECKING the motor is accomplished by means of the *spark* and *throttle levers*. The engine runs because it is supplied with an explosive or combustible *mixture* of *carbureted gas*, which is ignited by means of an *electric spark*. The amount and character of the gas—that is, its richness or poorness considering the relative amounts of air and gasoline vapor in it, are varied by the *throttle lever*. This is a small, finger lever, located on the underside of the steering wheel or attached to the steering post below the wheel so that it may be reached without taking the fingers off the wheel but by simply unwrapping them and extending them straight downward. Another position is above the wheel and within its dished-out surface, as in Figs. 1 and 2. This requires the driver to lift a finger of each hand over the top of the rim for operation, or in some cases to lift the hand off the wheel entirely.

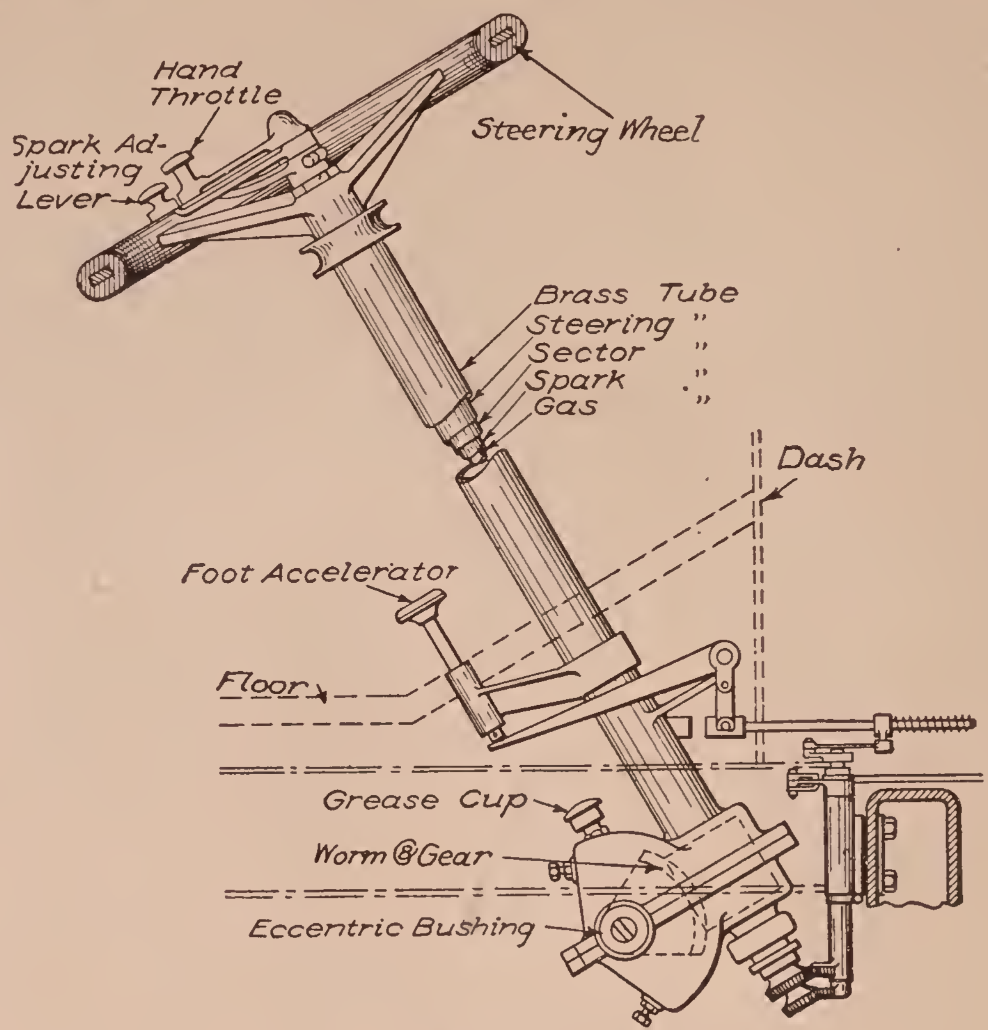


Fig. 7—A steering gear partly sectioned to show how the various levers operate.

The action of the motor resulting from movement of the throttle lever is as follows: Opening the throttle (by means of the lever) gives the engine more gas, and it speeds up at once or exerts more power; closing the throttle (by moving the finger lever in the opposite direction) gives the motor less gas and causes it to slow down and exert less power. After the driver has learned to run a car, he will find that a very large part of its operation is through the medium of the throttle lever, which thus becomes a most important part.

To explain this action of the throttle lever and what results, look at Fig. 8, in which it is shown in detail. In the pipe from the carburetor is placed the throttle, which may be of several types, that shown being the most common or butterfly form. This consists of a flat, round plate, the diameter of which is approximately equal to the inside diameter of the inlet pipe. When this is turned across the pipe at right angle to its direction, then it would fill up the opening entirely. In that case, no gas would flow and the throttle is said to be shut off or is spoken of simply as "off."

This flat round plate has a central axis on which it turns, and outside of the inlet pipe this carries a short lever to which is attached the system of rods

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down. Consequently, the engine choked up, receiving too much gas.

**48. When on low speed, and sometimes on second, the gears make a great deal of noise.** This is necessary and can not be avoided entirely. It is more noticeable because on the high gear, which is direct drive, the only gears in use are locked together and do not mesh, tooth to tooth. Consequently, there is no meshing and no noise caused by it. On changing to second or low, there are two pairs of gears or three as the case may be, in mesh consequently considerable noise. This can be reduced by using a thick lubricant and a small amount of sawdust in it.

**49. When using high speed, there are no unnecessary noises in the transmission, but on using any of the others, there seems to be a good deal of noise.** It may be that the lay shaft, on which the secondary gears are located, is loose in its bearings or shifts endwise due to poor adjustment and retention. This would make a great deal of needless noise.

**50. In changing speeds and throwing the gears as far as the levers will move, there is a great deal of grinding noise.** Apparently the adjustment of the shifting rods and levers for length is out, so that the whole movement of the hand lever does not give a complete

connecting it with the throttle lever on the hand wheel, which has been shown and described previously. A movement of this small finger lever then moves the flat throttle in the inlet pipe. Starting with this across the pipe or off, any movement of the lever will turn the plate out of an exact right angle to the direction of the inlet pipe, and thus will leave more or less of an opening at its ends—that is, the two parts farthest away from the central axis.

Now when the engine is turned over, the movement of the pistons within the cylinders creates a suction, and if the throttle lever has been moved to open the throttle slightly, some carbureted gas will be drawn in through these small openings. This will permit the engine to run, although but very slowly. When it is desired to run faster, the finger lever is moved, the throttle in the inlet pipe turns a little more, a larger orifice is created and more gas can be sucked into the cylinders. This will continue until the throttle plate has been turned so as to be parallel to the direction of the inlet pipe, when it will be open as wide as is possible and the maximum amount of gas will be allowed to pass through.

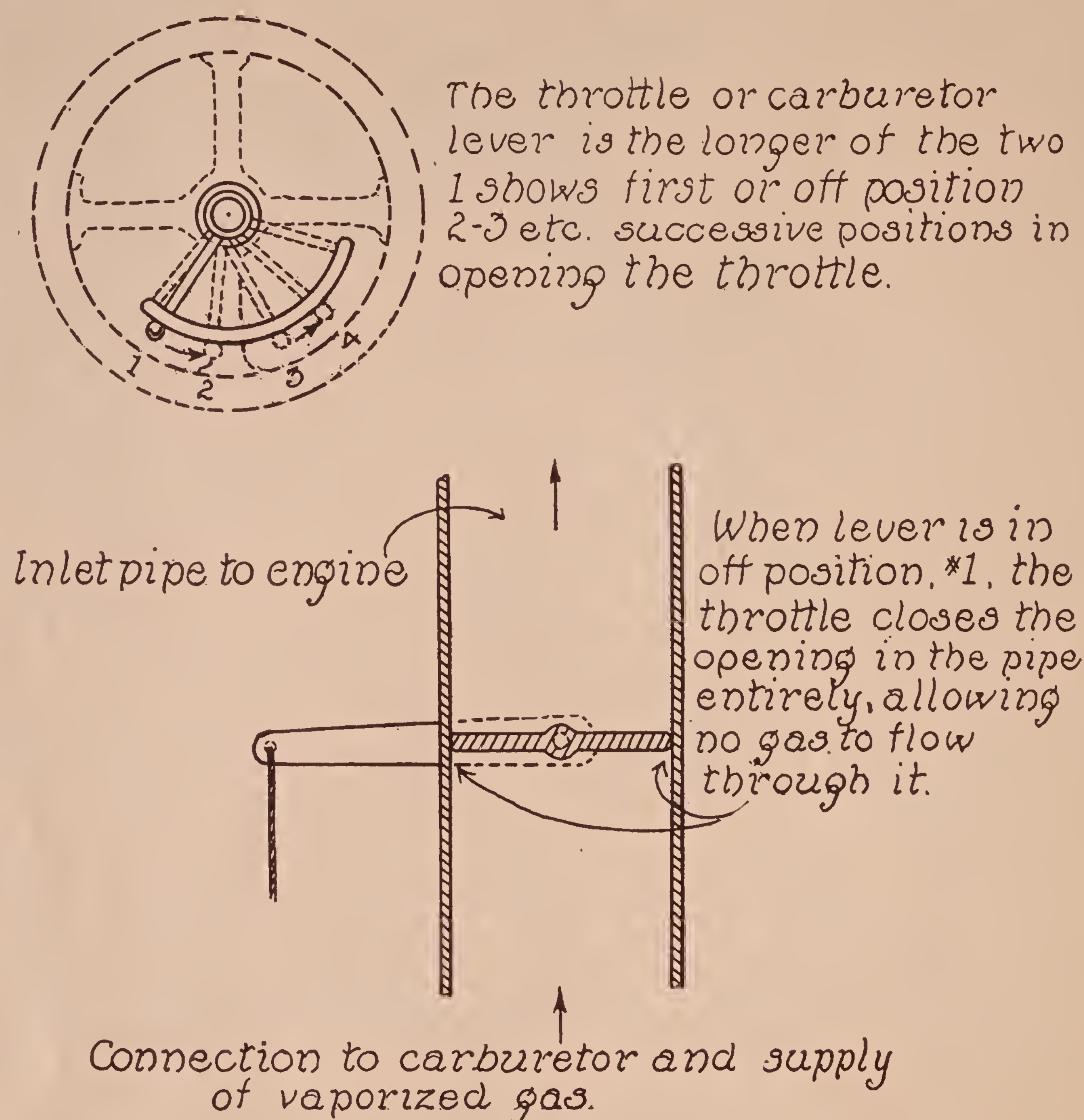


Fig. 8—The throttle lever and its influence upon the movement of the butterfly valve within the inlet pipe.

With the piston or other forms of throttle, some of which will be described later on, the action is exactly the same, the form of the throttle being the only thing which is changed. Some work more easily, others present a finer degree of

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movement of the gear. As a result, the gear is not entirely in mesh, consequently the grinding noise. Go over all rods and levers in this group with the cover off the transmission, and correct the length of those which are found wrong.

**51. What is the trouble when the gear lever moves easily at first but near the end of the motion goes very hard?** The teeth of the gear which is being shifted have become burred up, and scratch against the teeth of the gear with which it meshes. Fix this promptly, otherwise you may damage the second gear so that both will have to be replaced with new.

**52. How can this trouble be remedied?** Take the gear out and file off any projections above a plane surface. Use a fine file, and use it carefully. The metal will file away very readily.

**53. On some speeds the gears shift easily, and on others it is very difficult to move them. What is the trouble?** The shifter rod may have become rusty in its bearings at several points, so that when these are moved through the bearings, the motion is retarded by the rust.

**54. How can this be remedied?** Oil the shifter rod as much as possible, sliding this through the bearing so as to carry the oil with it.

variation from one extreme to the other, or still other advantages, but the principle of each is the same, the movement of the finger to open the throttle makes a larger available opening in the inlet passage for the gas to pass through.

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**THE SPARK ADVANCE** lever is the other one of the two finger levers, placed on or just below the steering wheel. This controls the position of the *electric spark* in the cycle of operation of the motor, and thus its speed and power output. A movement of the spark-advance lever in one direction advances the spark to a better position in the cycle, and thus the engine speeds up and gives more power. A corresponding movement in the opposite direction retards it or causes it to come at a later and poorer position in the cycle, with the result that the engine gradually slows down or gives less power.

The manner in which this finger lever works is very similar to that of the throttle lever. A movement of the former turns the contact breaker on the magneto backward so that it comes into action or "breaks" the circuit at an earlier point in the cycle of operation of the engine cylinder. This makes the spark, which occurs simultaneously with the breaking of the primary current flow, occur at an earlier point—in short, the spark is "advanced."

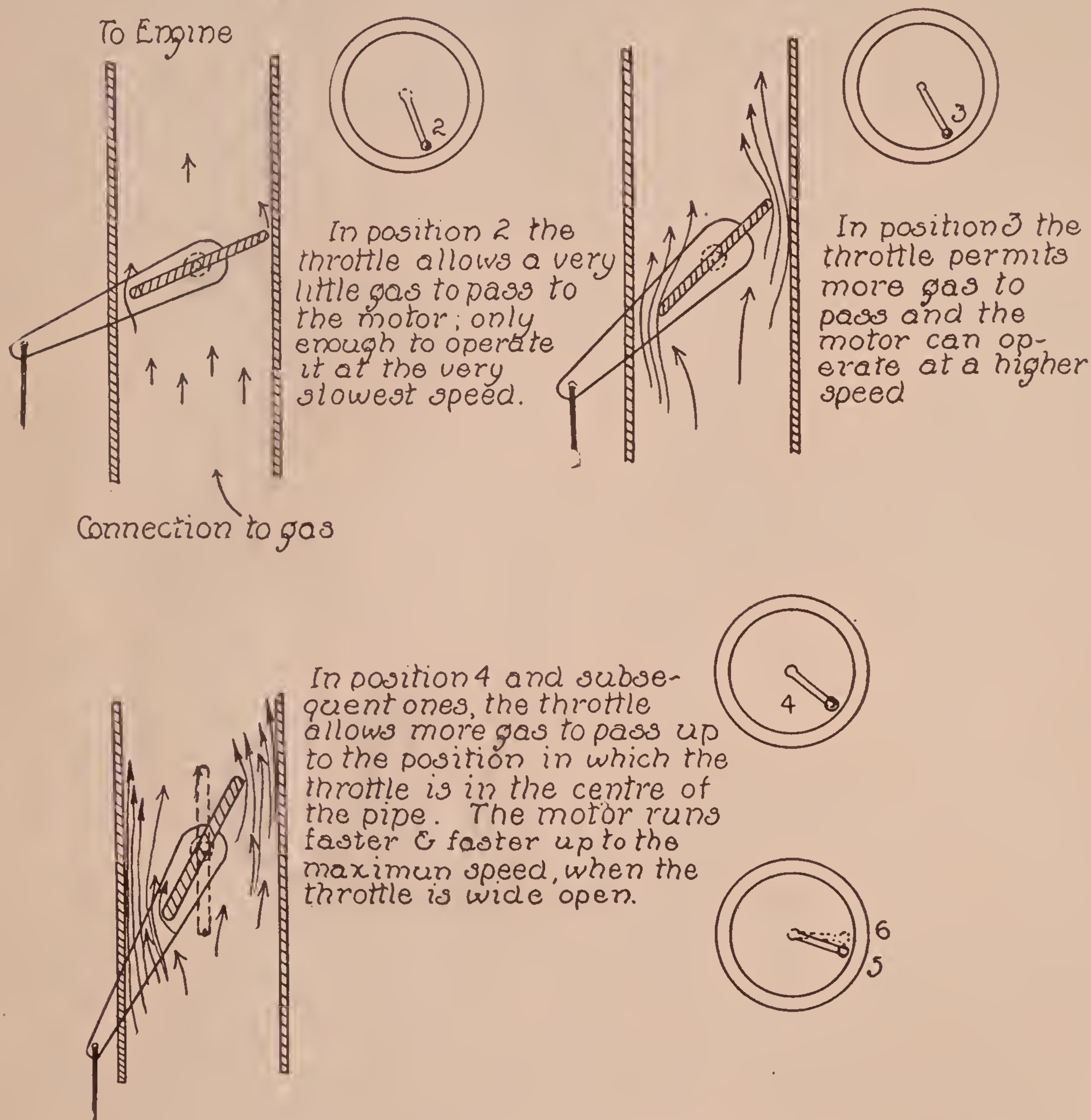


Fig. 8A—Later, consecutive positions of the throttle lever and its influence upon the valve and the consequent operation of the motor.

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If this makes the rod slide more easily, the trouble lies there. Take the shifter rod out, clean it thoroughly, then put in a vise and sandpaper the rusty part slightly, using a very fine paper or emery and lots of oil. After replacing, be sure to oil all over, and thereafter lubricate very frequently.

**55. The gear case seems noisy at all speeds. What is the trouble?** Probably not enough oil in the case. The lubricant deadens a great part of the necessary gearing noise. If the oil is too low in the case, these will be heard plainly all the time.

**56. What is the remedy?** Pour into the case a couple of quarts of the lubricant specified for this transmission, then run the engine and see if less noise is noticed. If so, continue adding lubricant until you have as much in the case as it will hold without overflowing or churning out when the gears are running. This is a wasteful method; do not use it unless the noise is unbearable. Ordinarily, the case should be filled only to the point where the bottom row of gears all dip into it slightly.

There are many gradual steps in this action, the last ones being almost unbelievable in their action. Normally, the spark is timed or created at a point in the cycle when the crankshaft has turned about 15 degrees down from the upper dead center, as shown in Fig. 9. When the piston pin, crank pin and crank shaft center lines agree exactly, the engine is said to be on dead center. In each cylinder this may occur at two points, when the piston and connecting rod are up and when they are at the bottom of their travel. The former is called the upper dead center and the latter the lower dead center. After the engine has passed the upper center and is turning in its proper direction, the spark is created at a point about 15 degrees down. Coming at this point, when the piston is traveling downward, the explosion of gas which results serves to drive it downward faster.

As the engine runs faster and faster, the spark is advanced or caused to come earlier and earlier. This means closer and closer to the upper dead center, until at very high rotative speeds, it may be created before the upper center is reached or the charge exploded while the piston is traveling upward. You would think that this would drive it down immediately in the opposite direction, but such is not the case. The inertia of the moving parts, as the flywheel, connecting rods, crankshaft and other, is sufficient to carry it over the dead center point before the downward force of the explosion begins to act. In addition, at very high speeds the parts are traveling at such a high rate that a considerable angle of travel is necessary for even such a very quick, almost instantaneous, action as the explosion of the gas. This at such a speed as 1,500 r.p.m., in a motor of 4-inch bore and 5-inch stroke, the motor is making 3,000 strokes a minute, or 50 a second. As each of these measures 5 inches, the piston is traveling 250 inches a second. One rotation takes 1/1,500th part of a minute, or 1/25th of a second. Ten degrees would be 1/36th part of a revolution, and consequently would require 1/900th part of a second. This is all the time that would be allowed for the spark lag and for the explosion to take place, if the spark advance were 10 degrees beyond the upper center.

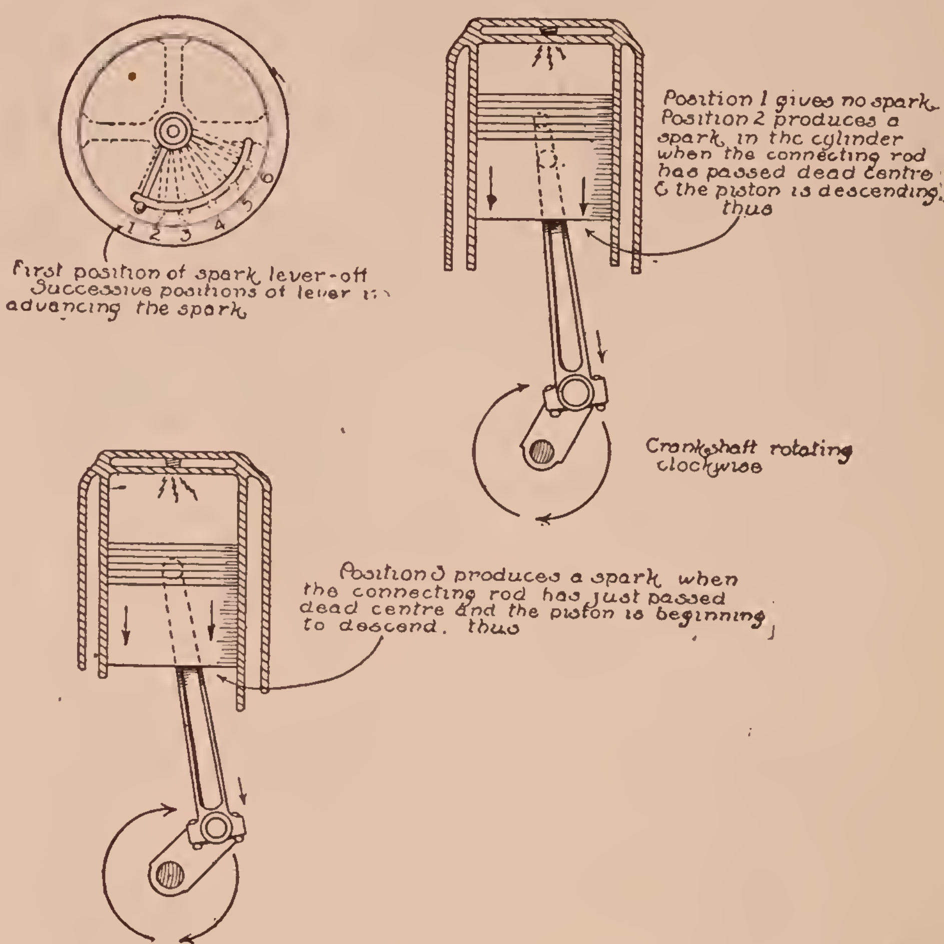

Fig. 9—The various positions of the spark lever and what happens within the cylinder at each.

Referring back to the two levers, the spark and throttle, these control the action of the engine absolutely, granting that the carbureting and ignition systems

**57A. When the brakes heat up very badly?** If the car is traversing mountain country or going down unusually steep hills, or fairly steep ones which have a poor road surface, the brakes must be used, and they will heat up.

**58A. Is there no remedy for this?** Pour cold water over the brake drums as soon as the heating is discovered and it is possible to stop with safety. This will cool them off quickly, while standing still, as will be necessary at the time of pouring on the water, will help also.

**59A. Is cold water the only remedy?** The driver should use his engine as a brake as much as possible in a case of this sort, since it is more or less beneficial to the engine, and saves the brakes at the same time.

**60A. Is there any particular advantage in the use of the motor as a brake, aside from those mentioned above?** It is more powerful than any hand or foot brake, or combination of these, and will hold the car in situations in which they will not.

**61A. How should it be used?** On ordinary hills there is little need for it On those of a considerable grade of many turns and some length, down which the driver does not dare to coast, and on which the service brake will not hold the car down to the speed desired, the high gear may be engaged, the clutch let in, and then the spark shut off. This makes the car pump in and compress gas, which is doing work. Even with small reduction, as in the high gear, this is very effective.

are operating properly. Moreover, if the engine is in a running condition, properly lubricated and otherwise right, no other levers or parts effect its running.

In the extreme off position of either lever, the motor will not operate, because without a spark the gas cannot be ignited, and without gas there would be nothing to ignite. The driver, knowing this, may slow his car down without using either clutch or brake, as outlined previously, by reducing the amount of gas to the engine and retarding the spark. The use of both together is very effective and pulls the motor speed down very rapidly. It is highly important for the driver to learn at the outset how to use the spark lever, as with this shut off entirely, the engine continues to pump gas in, *compress it,* and force it out. All this takes energy from some other source, so long as there is no spark to create an explosion and thus create power within the engine. The result is that the engine itself absorbs some of the energy of motion of the car, and thus acts as a brake to slow it down.

This cannot be emphasized too strongly, for there are times when the other brakes, strong and reliable as they may be, have not the strength and reliability that the motor used as a brake has. In mountain work, it very often is the case that the lining of the running brakes will be worn out completely before the descent is completed, in which case it would be necessary for the driver to use the emergency. This should not be done for several reasons, nor is it convenient. If the emergency is worn out in this manner, the driver is then practically without brakes of any kind and cannot descend farther without great danger. Using the brake lightly so as to spare it with this danger in mind makes it well-nigh useless. If the brake be applied somewhat strongly, there is danger of throwing out the clutch through the interconnection of the two, in which case the car will be in a position to coast down the grade, regardless of brakes.

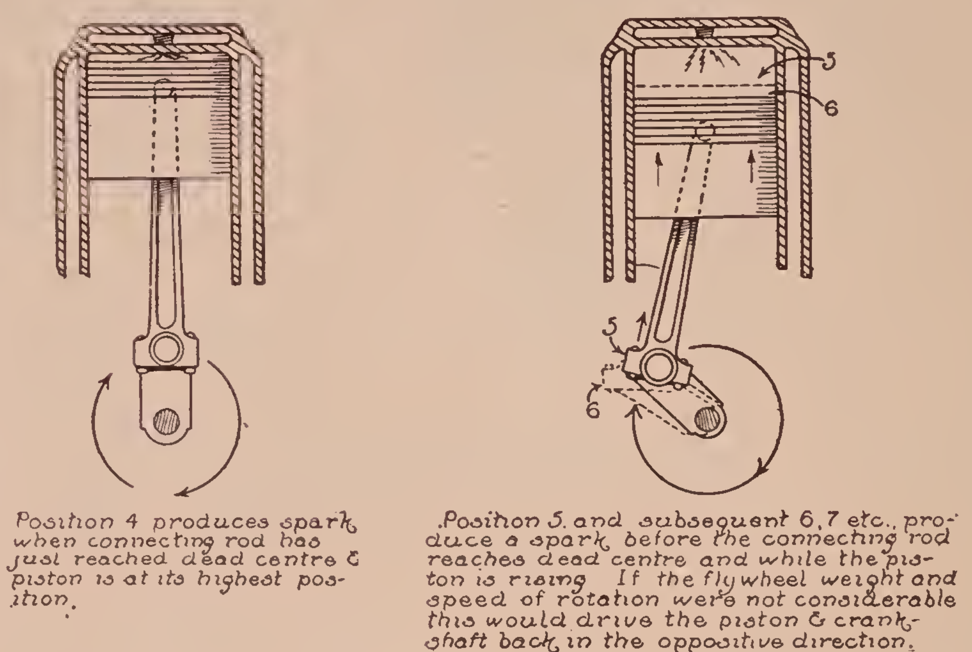


Fig. 9A—Later, more advanced position of the spark showing how this works without causing the engine to run backward.

Using the motor from the start—that is, shutting off the spark and letting the downward force of the car pump air or air and gas constantly—will keep the car speed retarded to a point where the very lightest touch of the running brakes will be sufficient to keep it well in hand. This will avert all danger, give the driver confidence in his car and himself, and preserve the running brakes throughout the descent. In addition, the pumping of cool air constantly through the engine cylinders will keep the engine from heating, a point which drivers must always have in mind in mountain work.

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**62A. On very steep hills and mountainsides?** Then the lower gears should be engaged and the same procedure followed. The same work is done, but it is multiplied between engine and wheels by the gear reduction. In this way it is possible to hold the car back with the low gear on the very steepest grades which it is possible to travel with safety in a motor car.

**63A. On such grades as coming down a mountainside, what special precautions should be observed?** Great care should be exercised to keep the speed of the car down, before striking the heavy grades. That is, instead of waiting to reach the actual grade and starting down it before checking the car speed, it should be checked as much as possible before starting down the hill. If this be not done, the brakes will have to absorb the entire energy of the speed of the car, in addition to holding it back against the force of gravity acting on it. Cases have been known in which adequate brakes and large-sized engines failed to hold a car going down a mountain grade because the motorist did not follow this simple rule, and started down the steep hills at a fast pace. Even the combination of brakes and engine was not sufficient to stop it when once it got rolling rapidly down the mountainside.

**64A. When clutch is thrown out, the gear shaft continues to rotate?** This indicates what is known as "spinning," the clutch shaft continuing to rotate after the clutch has been thrown out, so that theoretically it should stop. To the novice, this condition is peculiarly annoying.

On the level, as well, the engine is useful, and serves as a powerful air brake for stopping the car when a sudden danger is manifest. The action of the fingers in shutting off the spark or both spark and throttle is so quick and the response so rapid to this tremendous load which has been suddenly substituted for the previous pulling power that any driver who has ever tried it will never discontinue the practice. The fingers can make this movement of reducing the spark to the zero point so quickly that no other movement which might be made toward the other brakes can compare with it in point of time used.

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**THE HORN** or *signalling device* is used for giving notice to others of the approach of the car. If this be not done, the law holds that the driver is liable for all damages and injuries sustained. For these reasons, it is highly important that the novice learn the location of the horn, its method of operation, and gradually form the habit of reaching for this as soon as he approaches any kind of crossing or other vehicle. In a short time, he will get in the habit of doing this involuntarily, and thus it will not detract from his attention to the control of the car.

In general, there are two types of horns in use, and as their operation is radically different, it is important to mention both. The electric horn is coming into very general use. This is operated by means of a push button located on the steering wheel, on the outside of the driver's seat, or in any other convenient position. The current is furnished by means of a storage battery, carried in any convenient place. The current used is exceedingly small, so that battery exhaustion needs almost no consideration. The position of the push button makes the operation of this form so simple that it has no competition in this respect.

With the bulb horn on the other hand, or any mechanical form which requires physical force to operate in the form of turning a crank, pressing a pedal or button down several times or squeezing a rubber bulb, the position of the operating part is a most important item, for it must be so placed as not to require any extended movement, necessitate much reaching or other exertion, nor call for any thought, since the driver usually will be spending all his thought on other matters. Thus, with a bulb horn, if the bulb be set too low or too far from the driver, he will have trouble whenever he must operate it. If a condition arises in which the operation of the horn, with its accompanying reaching or stretching, necessitates neglect or the overlooking of something more important, a serious accident may result.

A driver should be fair with his horn, and not sound it upon every possible occasion. There are many persons who are timid about a machine moving as swiftly as does the modern automobile, and these jump whenever a horn is sounded. In such a case, the driver is almost justified in not blowing or sounding a warning signal, as this would cause more trouble than the lack of it. Many times a skittish horse or other animal will be so terrified at the sound of a horn as to become unmanageable or to run away. Here again is a case in which the driver should use his best judgment, conditions often bringing about a situation in which it is not well to use the horn too freely, if at all.

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**65A. What causes it?** For one thing, the design may be bad—that is, the clutch may have been designed with too much metal around the outside, so that it has considerable flywheel effect. Another possibility lies in the disengagement being less complete than the driver thinks—that is, throwing the clutch pedal all the way out may not throw the clutch itself all the way out, but leave it in partial engagement so that it continues to run a little bit. A third possibility lies in the condition of the clutch leather or lining. This may have such a surface that when the pedal is thrown out, while the clutch is disengaged, a portion of its surface is enough higher to remain in contact and thus give a partial rotation now and then.

**66A. How can these be remedied?** The first can be fixed by taking the clutch out and having a machinist take off as much metal at the inside of the outer rim as is reasonable and safe. This should be done with great care in order not to destroy the balance of the unit. The second trouble can be remedied by readjusting so that the same movement of the pedal moves the clutch out farther. The third trouble calls for thorough inspection of the clutch leather or lining. If found in bad shape, the remedy may be a new lining. If in good shape, a coarse file may help the spot or spots which have been giving the trouble.

**67A. The clutch engages all right, but acts stiff and harsh?** This trouble is a common one, and is due to a lack of oil in the leather of the lining. Neatsfoot oil is the only kind which should be used.

On the other hand, every driver should give sufficient warning of his presence as to render the use of the highway, either as a thoroughfare or at crossings, safe to all concerned. The point which is most often raised against the modern silent machine in cases of accident is that automobiles are not so quiet that unless a signal of some sort be sounded by the driver pedestrians will not know of its approach until they see it accidentally or otherwise.

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**CHANGING SPEEDS** is done by moving the *speed lever* at the driver's side. This may be the inner or outer lever, but usually is the inner, nearer one. It has a double motion—forward and back, and from side to side. The lever works in a *quadrant* or slotted plate, its position therein indicating the speed which is engaged. Thus the usual three-speed device has a four-slot quadrant—that is, two slots in front, one on each side, and two in the back, one on either side. These are for the reverse or backward speed, the low or third speed, the intermediate or middle speed, and the first or high speed, a *transmission* being named according to its number of forward speeds.

One peculiarity of the *gasoline engine* is that it cannot start under a load, but must be started first, allowed to run a short time, and then the load gradually applied. For this reason, an automobile engine must be started, allowed to get up speed, then the light load or slowest speed applied, after which the driver may proceed to use in order the higher speeds as he desires, going from low to second, to first or highest speed.

In this he must remember that the engine is running constantly and that the *gears* in the transmission or gear box are engaged or disengaged by sliding the teeth of one into contact with another. Doing this while either or both were rotating would result in grinding off or breaking off the teeth of both and thus rendering them useless. With the gear box out of commission, the car would be useless also.

For this reason, the engine or source of power must be disconnected from the gears whenever a change is to be made. This is done by throwing out the clutch, through the medium of the clutch pedal, as explained previously. When the engine has been disconnected for a short while, the gears will slow down and almost stop rotating. At this moment, the other gear, which is to be engaged with the moving member, is quickly and dexterously jerked into place by means of a very rapid movement of the hand lever operating the gear changes.

After this movement of the hand has been perfected, the driver will be able to move the handle over and forward or back, as the case may be, simultaneously and as quickly as possible. Some drivers become so skillful at this that one never notices the change of speed of the car or hears any noise. As soon as the proper gear is engaged, the clutch pedal is allowed to rise slowly, so that the clutch will take hold slowly and thus gently. If the foot be removed at once, the spring will jerk it into place, the engine will grab hold of the gears, and the car will be jerked along for some distance. By allowing it to take hold gradually, the car is picked up without any of that irregular movement.

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**68A. How is this applied?** Throw the clutch out as far as possible, then pour the oil onto the projecting edge of the leather. If possible, block the pedal in the extreme position, then apply the oil with one hand and rotate the clutch with the other. In this way it will be distributed around the entire circumference, and through use will cover the whole surface of the leather.

**69A. When the clutch slips out occasionally?** The trouble is the spring is too weak, and should be tightened up, or, if tight, should be replaced with a new one. Generally, there is a locking mechanism to be contended with, but this is easily backed off, then the adjustment made, and the lock put on again.

**70A. Suppose a clutch, when thrown out, does not stop operating?** There may be a stop on it which is wrongly adjusted and which prevents it from going all the way out, as the movement of the pedal would lead the driver to think.

**71A. Is there any remedy for spinning?** Yes; a stop can be rigged up if the car does not have one, this being in substance a small and very simple brake which comes into operation only when the clutch is thrown out. Generally, it consists of a small pad of leather, fiber or similar material attached to a spring arm in such a way that when the clutch is thrown out, some projecting portion of it comes in contact with this, and is prevented from rotating by it.

**72A Suppose a clutch throws a good deal of oil?** There must be a bad leak somewhere, or else the method of lubricating the clutch is wrong. A clutch should not throw off any, or at least any appreciable amount, of lubricant. When it has just been softened with Neatsfoot oil, it will throw off quite a

This is a combination movement which is difficult to describe, but fairly easy to learn. The throwing out of the clutch is performed by means of a quick downward thrust of the foot, but letting the clutch back in is just the opposite; it is a very slow movement. The idea of doing this so slowly is to allow the clutch to engage gradually and thus start the car without shock or jerk. If the clutch be slapped in as quickly as it is withdrawn, the engine will grab hold of the car and start it with a jerk or series of jerks which may unseat the passengers. At the very least, it will be disagreeable to all concerned, while this method of procedure will not do the gears and other parts of the vehicle any particular good.

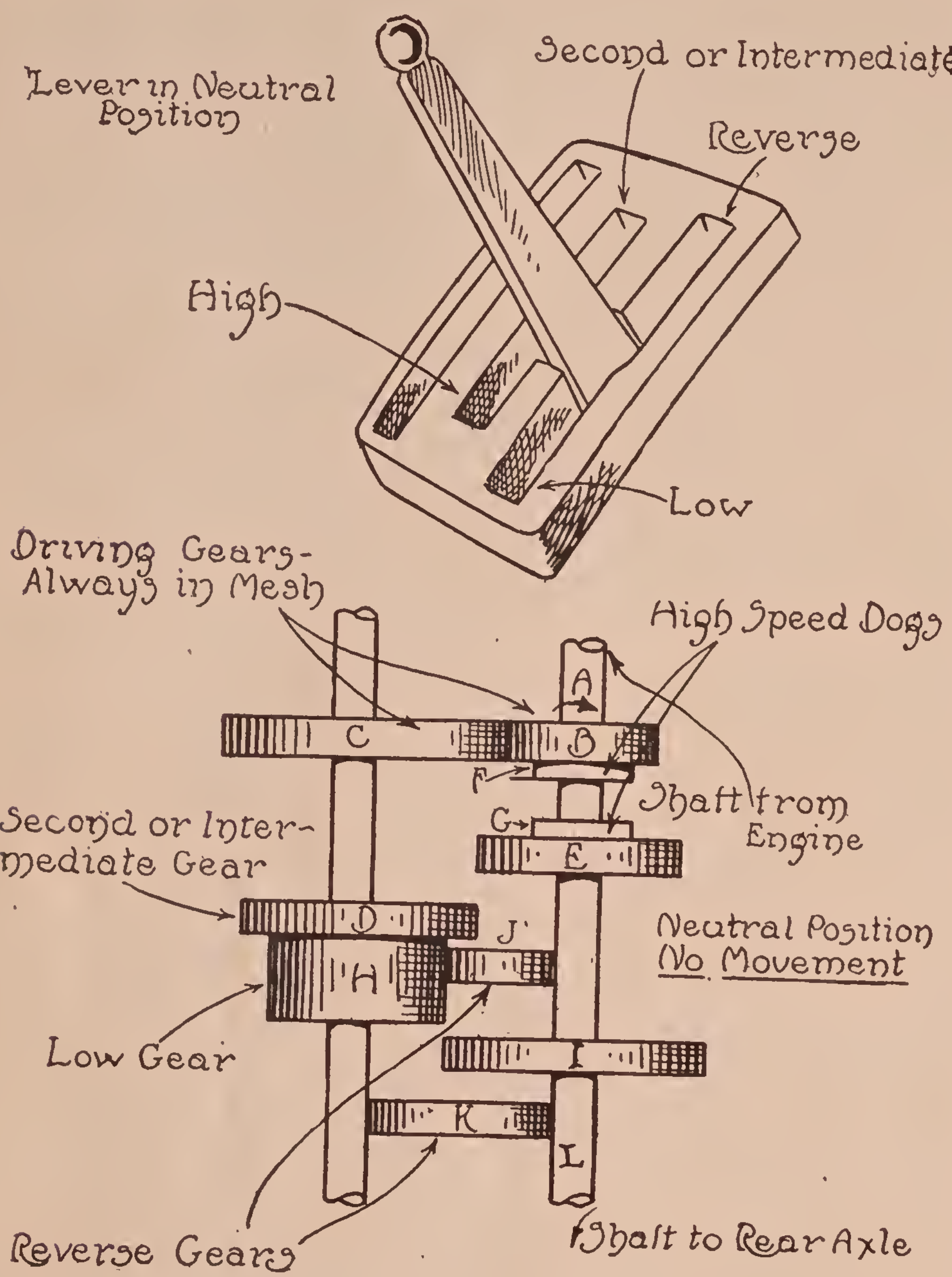


Fig. 10—Operating the transmission gears. Sketch to show the components and their relation when the lever is in Neutral.

The process of shifting gears is more or less of an intricate one, and every driver should learn to shift from any speed to any other so well and so thoroughly that he could do it in the dark if necessary. When he knows it as well as this, he will be able to make the change from one speed to another without looking down at either lever or quadrant. This is the proper way, for then he can give all his attention to the road ahead and its dangers while changing speeds.

The whole process of changing consists, then, of the sudden throwing out of the clutch, grasping the transmission lever, shifting forward, then across or straight forward, and then either forward or back, as the case may be, according to what the change is from and to. Next the clutch is allowed to engage gently. The best results are obtained when the skill of the operator and his dextrous manipulation of the lever is such that the change from one gear to another is made almost instantaneously. The clutch must be out before the first gear is disengaged, but after that a very quick and skillful operator will not require any more time for the change than that necessary to let the clutch back in again.

The reason why the clutch must be disengaged for the change of gears is simple. The engine has the car in motion and is furnishing power to continue to

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little for a few days, but that is all. Beyond such a case, it should not throw any.

**73A. When standing on the garage floor, the transmission leaks lubricant, making quite a puddle on the floor in a short time?** This indicates a bearing which allows the lubricant to pass, at the front or rear end, and a stuffing box which is not working. Either one of these or the case is cracked somewhere sufficiently to allow the stuff to pass through. Look into this matter, as the matter may be no more than the need of a new felt washer on one of the stuffing boxes. On the other hand, a cracked transmission case means a makeshift patch or a new case. Either of the latter is quite serious. Similarly, the leaking lubricant may not do a great deal of harm to the garage or other floors, but it is a dead loss, and soon will empty the case entirely when the bearings and gears will not have any. This latter is a serious condition, particularly if it happens or is brought about out on the road when no fresh supply of oil or grease is handy or available.

**74A. Suppose the gasoline pipe leaks slightly, enough to show a pool of fuel, when it has stood for half an hour?** This is more serious than a lubricant leak, as the leaking fuel might be the means of setting the car on fire. It may be that the strainer has become filled with sediment and needs emptying. There should be a cock in the line above this, and close to the tank. Shut this off, and take out the strainer to see if it needs to be cleaned out.

drive it. If this power were not disconnected, during the shifting process there would be a brief space of time in which the drive would be carried by a very small portion of the surface of two gears—too little, in fact, to carry it—and both would be stripped. A second reason has to do with the progress of the car and the rotative speed of the gears. Generally speaking, the gear which the driver is about to disengage and the one which he is about to put into mesh are rotating at different rates, one of the former being driven by the engine, possibly direct so that it is turning at the maximum rate, while the other is being driven, if at all, by the car and at car speed. The latter will always be less than the former, and it would be unwise to attempt to mesh or engage two gears rotating at widely different rates, particularly if much power is behind either one. Throwing the clutch out leaves one gear, the shifter, turning idly, and it will slow down very rapidly to no rotation at all.

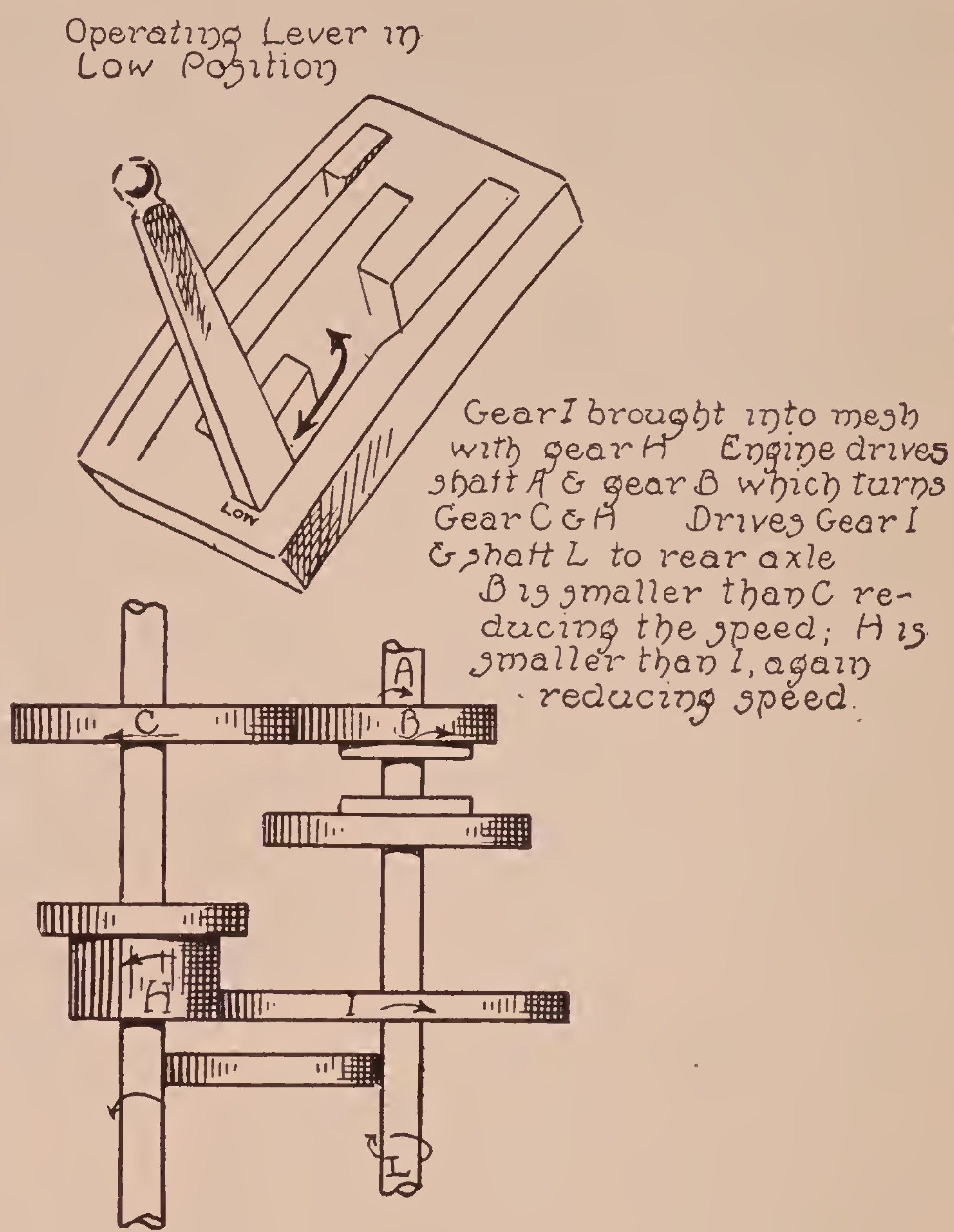


Fig. 11—Position of the operating parts of the transmission when the lever is in the low gear position.

Before this happens, the driver should have meshed it with the one intended; in fact, the best drivers would pause for such a fractional part of a second as is required to bring the higher speed of the shifter down to the slower rate of the other, and no longer. That is, he will make the change at the exact instant when the two gears are turning at precisely the same speeds.

Many a man knows how to handle his car and shift gears perfectly, long before he knows just what happens inside the gear box. Yet this is a very simple matter to explain. In Fig. 10 the gear shifting lever is indicated and the position of the gear which it brings about. The following sketches, Figs. 11, 12, 13 and 14, bring out what happens when the gear shift lever is moved. First of all, it moves in an H-shaped quadrant or sector, the position of the lever in this indicating the speed which is engaged—that is, all except the cross bar—position there meaning the neutral position in which no gears are engaged.

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**75A. Suppose a case as above, and the strainer is found to be clean and not clogged up?** Then there may be a slight crack in the gasoline pipe leading down from the tank. If this line is badly bent anywhere or twisted to a considerable degree, look it over carefully at these points. Aside from the danger of fire, the motorist does not care to be losing fuel all the time, the small leak might burst open on the road somewhere and leave him stranded 10 miles from everywhere, with no fuel available.

**76A. What makes the car springs squeak?** Generally rust between the leaves. This can be remedied by prying them apart and inserting a thin lubricant made up of oil and graphite. Some motorists use a hammer and screwdriver or chisel for opening the leaves, but this is not necessary, as there are several tools now on the market for doing this work. The car should be jacked up above the springs, so as to take all weight off of them. Otherwise, prying them apart is a difficult job, and is liable to end in breaking the ends off a number of the spring leaves.

**77A. In general, what causes a squeak?** Except in a few cases, where wood rubs on wood or metal, or is itself twisted by the movements of the car on rough surfaces, squeaks are caused by a lack of lubricant. If a metal surface rubs over, touches or works upon another hard surface, whether wood, hard fiber or other metal continuously, a squeak is likely to result every time the one is moved forcibly across the other. If the driver hears a squeak and wants to cure

Starting with this neutral position, as indicated by Fig. 10, the gear lever will be shifted successively through low, second, high and reverse speeds, as shown in the other figures. In each case, it will be remembered that the clutch must be considered and operated, although for the sake of clearness nothing will be said about this. In a transmission of the kind indicated, the gears are arranged so that within the transmission case there are two sets of shifters—one for the low and reverse speeds, the other for second and high speeds. On the quadrant there are two members to which the shifting members are fixed by the simple act of moving the lever into the plane of the outer opening or slot in the quadrant and the plane of the inner slot. Picking up these members picks up one or the other of the shifting groups inside the gearcase, according to the movement of the gear lever across the quadrant. This sliding-across movement, then, is a definite part of the act of shifting gears and constitutes the middle part of a change of speed.

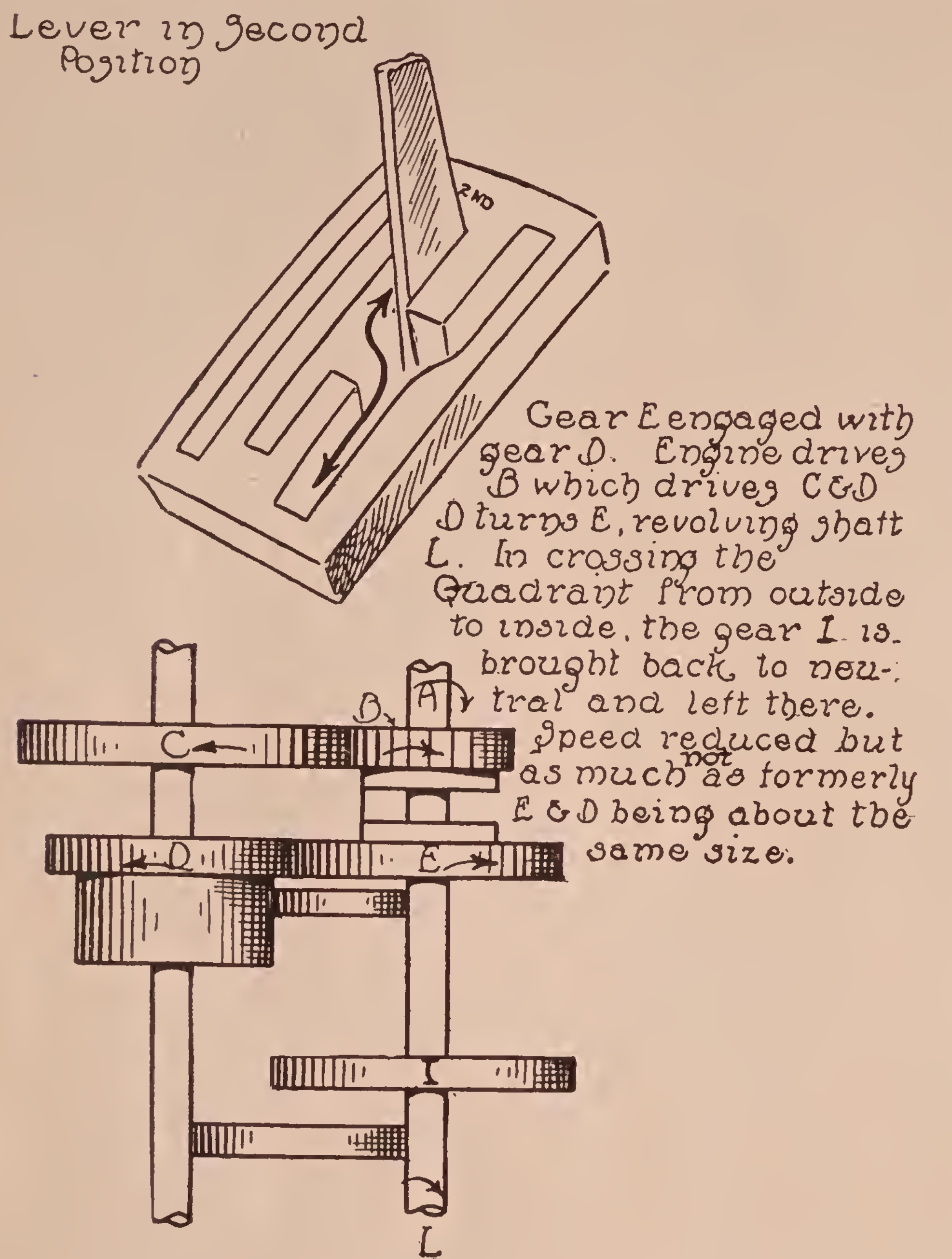


Fig. 12—Relative position of the change gear parts when the operating lever is in the second speed or intermediate location.

In addition, there is the movement of pushing the lever forward or pulling it back, which slides a gear within the transmission case in the opposite direction. This action constitutes the first and last parts of a gear shift. Thus, consider Figs. 10 and 11, neutral and low speed. From the former to the latter, the first act is the sliding across the quadrant of the lever which picks up the low and reverse group of gears inside the case. Then pulling the lever back as far as it will go pushes the gear in the case as far forward as it will go, in which position it meshes up with another to produce low speed. This means that the driving member is much smaller than the driven, so that it must turn several times before a complete turn of the latter results.

Now compare Fig. 11, which shows the low speed engaged, with Fig. 12, showing the second or intermediate speed. To make this change, the lever must be pushed forward to the crossbar of the quadrant, and then slid across to the

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it, he should start out with the oil can looking for it. Many body squeaks are caused by insufficient or inadequate fastenings, so that a few more nails, screws or bolts judiciously applied will remedy the noise.

**78A. In steering around a curve what is the proper way to turn the wheel?** Turn it gradually so that the car comes around in a series of gradual turns, and not jerk it around with one big sweep. The latter may be spectacular, but it is hard on the tires and especially hard on the steering gear.

**79A. Is it advisable to steer with one hand?** Not for the novice. It may be all right for the expert, but even he should use both hands whenever the country or the roads present an element of danger, as in mountain climbing or descending, passing teams, other vehicles or pedestrians.

**80A. In case of breakage of any kind in the steering gear, what should the driver do first?** Shut off the power as quickly as possible, then apply all brakes immediately. The idea is to bring the car to a stop as quickly as possible, regardless of results to the car itself. That is stopping quickly at such a time is more important than wearing out the brake lining, wearing some rub-

inside. Doing this throws the low-speed gear out of engagement, and the sliding movement disconnects the lever from that group of gears. Sliding clear across to the inside connects with the other group, which will give second and high speeds. Then pushing the lever forward as far as it will go shoves this shifting gear as far backward as it can travel within the gearcase and safely into mesh with the second-speed gear.

Comparing this with Fig. 13, high speed, it will be noted that as the lever is connected to the shifting gears which produce high, it is only necessary to pull the lever backward to the extreme rear end of the slot, when the high-speed gear will be engaged. The first movement pulls the second gear out of mesh, the middle portion of the action brings the two gears up close to one another, while the final shove engages them. Attention is called to the fact that this gearbox has the direct drive on high gear, the two shafts in the transmission being connected together by means of jaw clutches when this is engaged, so that the drive is direct through from the engine to the rear axle, the only reduction in speed being in the bevel gears at the differential. This eliminates all the small losses incidental to the use of two pairs of gears, as in each of the other cases, and makes this not alone the combination which produces the greatest speed but also that one which gives the maximum efficiency and economy.

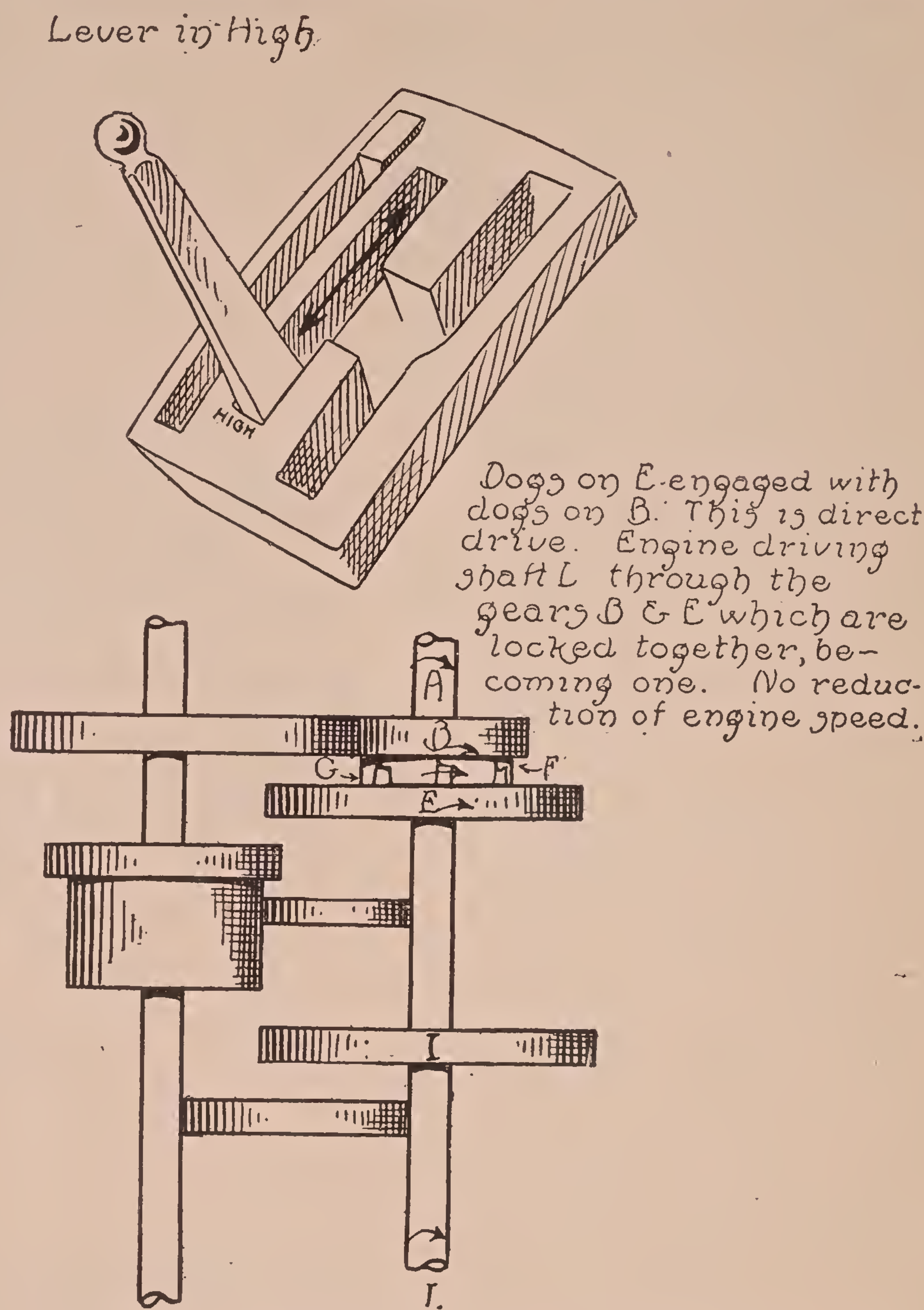


Fig. 13—What happens within the gear case when the lever is thrown into the high speed position.

Referring to Fig. 14, and comparing it with Fig. 13, this combination would be a direct shift from high speed to reverse. This is one which would never be met with in practice, as such a shift would be very likely to smash something, the sudden strain of the shift from high speed in the forward direction to the lowest rate in the opposite direction being too much for gears and other parts to with-

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ber off the tires, or any such minor matter.

**81A. In case of a puncture or blowout, how should the driver proceed?** Throw out the clutch and let the car come to a standstill as it will, unless it manifests a tendency to keep right on running for some time, as would be the case of a long, gentle grade.

**82A. What is the idea of not applying the brakes and stopping quickly?** When a blowout or puncture occurs, and the brakes are slapped on as quickly and as strongly as the tires are not in any condition to grip the ground and thus stop the car. Persistent use of the brakes under such circumstances may ruin a tire, which otherwise had but a small or comparatively small hole in it.

**83A. In the case of a tendency to keep on running, why is it advisable to brake the car gently to bring it to a stop?** The tire being deflated the weight of the car is being borne on the delicate inner tube or pure rubber. This can not be continued for any distance without cutting it to pieces. At

stand. It is shown here, however, more for the purpose of indicating how the various changes are made and what actually happens when this or that lever is moved than as indicating good practice. First the lever is moved forward to the cross slot, thus disengaging high speed, then it is slid across, which drops the high and second-speed member, slid clear to the outside, which picks up the low and reverse shifter, then pushed forward as far as it will go, which moves the shifter as far toward the rear as it will go, and thus meshes with the reverse gear.

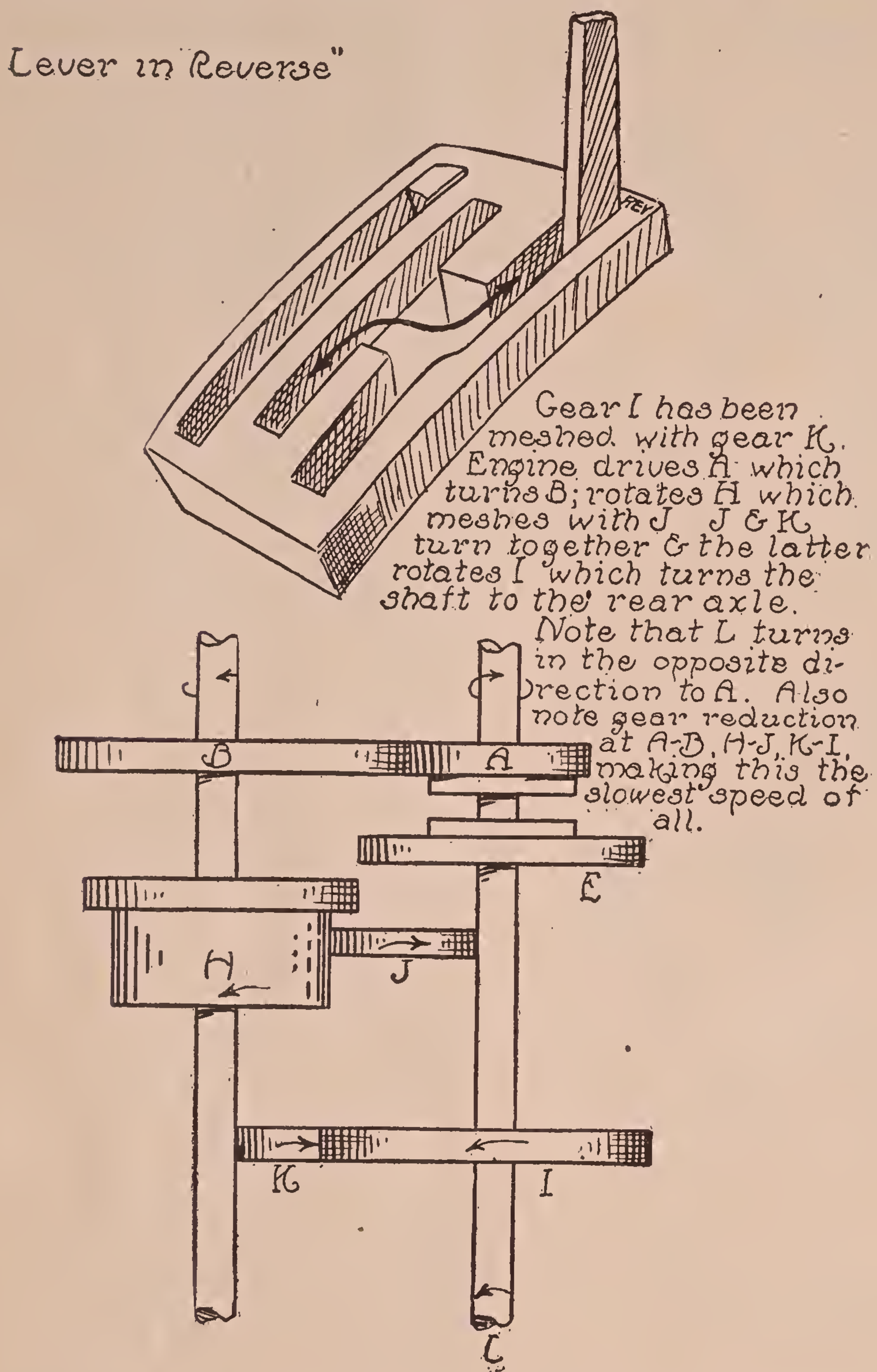


Fig. 14—Location of the parts and relative movement when the lever is put into the reverse gear notch.

Noting the letters on the various parts, gear *I* is now in mesh with *K*, which is on a short shaft beneath the other two. This carries at its forward end the gear *J*, which is constantly in mesh with gear *H*, and as a result is driven by it continuously. Thus the drive is from the engine shaft *A* to the gear *B*, this turns *C*, and thus the gears on the secondary shaft. One of these is *H*, which meshes with and turns *J*, this in turn operating *K*. When *I* is meshed with the latter, the train is complete, and the shaft to the rear axle *L* is operated by the engine power, but in a reverse direction. The latter is brought about by the use of three trains of gears, as compared with two in each of the other cases. These are: *B-D* direct through the jaw clutches *F* and *G* for high, *B-C* and *D-E* for second, *B-C* and *H-I* for low, and *B-C*, *H-J* and *K-I* for reverse. If the arrows have been followed through in each of the five figures, these various combinations will be seen as even more simple than telling about them is.

As every higher speed means a heavier load for the engine, and every lower speed a lighter load (except when in deep sand or climbing a hill), the operator

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possible, a violent skid often occurs. In addition, from the nature of the accident, most, a puncture means a patch; a blowout, unless very bad, a large patch, while running so as to ruin the tube means a new one. The difference between a personally applied small patch, a vulcanized large one at 50 cents, and a new tube at from $7 to $10 is considerable and worthy of a little thought.

**84A. In steering, the wheel turns several inches in either direction before the wheels begin to move.** This is termed lost motion, and is caused by the key which holds the hand wheel to the steering post becoming worn. Even the smallest fraction of an inch of wear on this key will allow several inches movement of the wheel.

**85A. How is this remedied?** By taking off the wheel and taking out the key. If the keyway or keyseat in the wheel is still straight and true, the trouble can be remedied by fitting and driving in a new key. If the wheel is worn, however, it means that this must be recut to a slightly larger size, and then a new key of the larger size fitted and driven in.

should open the throttle and advance the spark lever just before he makes the change to a higher speed, or just as quickly as it is completed, and just the opposite with a lower speed. In general, it is better to speed the engine up beforehand, but some skillful drivers prefer to make the gear shift first and then change the engine speed immediately after. If this be not done, the extra load in one case will cause the motor to slow down and stop, or speed up and *race* in the other. Neither one is desirable nor good driving.

The change of engine speed (by means of the spark and throttle) should not be made too late—that is, too long after the gear change, as then the tendency is to kill the engine, which is another way of saying make it stop. Thus if a change is made to a higher gear and the engine begins to labor and slow down very markedly before the driver begins to give it more gas and greater spark advance, the sudden addition of a big amount of both these when the engine is dying down will but make it stop quicker.

# CHAPTER II.

# The Auxiliary Control Group.

**THE AUXILIARIES** of the operating system are those additional parts which contribute to the ease of handling a car but are not to be found on all cars, or cannot be handled until the driver has acquired a certain amount of skill in operating his car. These are eight in number, as follows:

1. The accelerator or foot throttle.
2. Needle or auxiliary air variator on the dash.
3. Muffler cut-out button.
4. Lubrication telltale.
5. Signs of motor heating.
6. Unnecessary noise.
7. Lack of regular operation.
8. Starting and the attendant operations.

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**THE ACCELERATOR** or *foot throttle,* as its name indicates, is a small button somewhere on the inclined footboard of the driver's part of the car, arranged to be operated by a slight movement of the toe, usually of the right foot. It opens the throttle of the carburetor more quickly than the finger lever on the steering wheel, and thus it has the double function of leaving the hands free for something else and of working the throttle variation, especially opening it, more quickly than is possible with the hand lever. Not all cars have it, nor do all drivers who have it utilize it. In such a case as this, it is very useful: Suppose a car stopped at a railroad crossing, which has just cleared so that the car may pass, when another train is seen in the distance. The throttle is kicked open, and the car shot across the tracks to avoid the second delay.

This accelerator not alone operates more quickly than the hand throttle, but it has the prime advantage—which is of equal or greater weight—that it may be operated by a body member which is not required for some other operation of equal or greater importance at the same time. Thus consider again the case just cited: The car has been stopped and presumably the emergency brake applied. Starting up again quickly, the left hand is needed on the steering wheel for guiding the forward motion of the car across the tracks and may not be used for

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### Automobile Troubles and How to Remedy Them

**57. When driving on the accelerator—that is, with the foot—the car alternately runs too fast and then too slow, what is the cause?** The driver has not yet learned to use the accelerator pedal properly. He depresses it too much at the outset, causing the car to run too fast, then he forgets to keep his foot pressed down on it, and the car loses speed because it is not getting enough gas.

**58. What is the remedy for this?** Take the time to practice holding the foot in one position without varying by the slightest fraction of an inch for hours at a time. If you cannot master this, nail a piece of board to the footboard in such a way that it will allow of holding the throttle open as much motor at once; any motor will knock if asked to change from 10 to 45 mph in as short a as is wanted at usual speed. Then as soon as the car is started, press down on the foot until it touches the board. Hold it there. This holds the accelerator open just that much, and the leg muscles are becoming accustomed to holding that position for a very long time. As soon as this has been perfected, take away the extra board and try doing the same thing without it.

**59. When approaching a hill at a slow speed —say, 10 mph—and then pressing down on the accelerator in order to climb the hill, the car picks up speed rapidly but knocks badly.** The trouble is that too much gas was fed to the

anything else. Similarly, the right is operating the brake and gear levers so that it may not be used for anything else. It is important, however, that the car reach its maximum speed as quickly as possible.

Without the accelerator, this would be a slow process; the brake would be released first, then the motor speeded up a little and the car started forward. Next the shift would be made to second speed and the hand would have to go back to the steering wheel a second time in order to speed the engine up a little more. When this has been done and the motor has attained the higher speed, the hand must go back to the lever at the side for another change to high gear. Following that, it would go back to the wheel again for the final adjustment of spark and throttle levers. With the throttle, all of the engine speeding operations would be done by the toe of the right foot, which otherwise is doing nothing, and simultaneously with the hand operations on brake and gear levers. In short, not only would the constant moving of the hand from lever to spark and throttle and back again be avoided, but by doing it with the foot at the same time, a considerable number of seconds will have been saved at a time when even seconds are valuable.

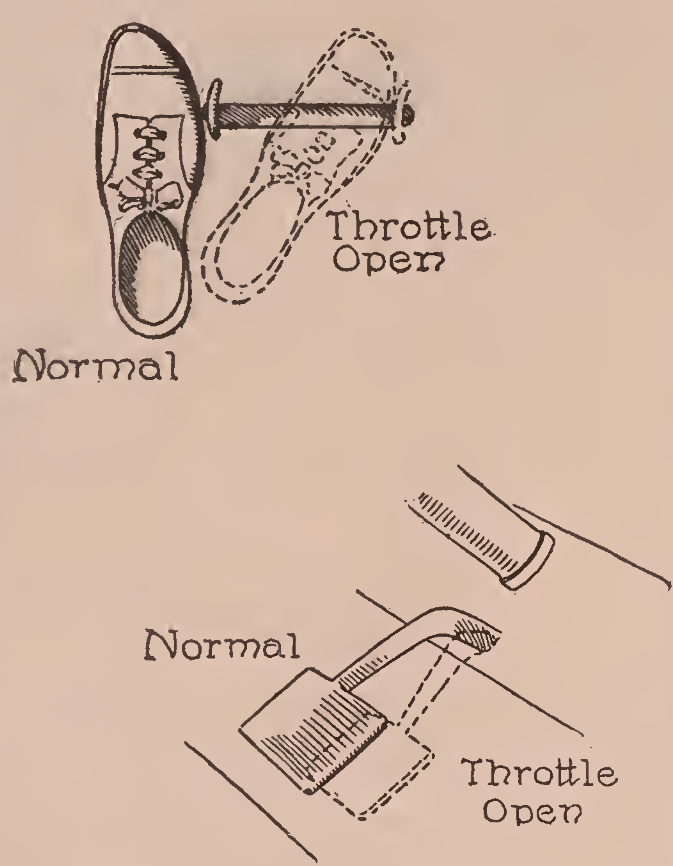

Fig. 15—Two forms of accelerator pedals, showing (above) that which is moved sideways by the top and (below) that which is depressed like a clutch pedal. Both are from well-known cars.

The operations just described have this further advantage for the accelerator pedal that there is at no time a chance for the driver to get mixed up and do the wrong thing, thus mixing up matters very badly. In the case cited above, the constant movement from throttle to spark to hand lever, back to throttle to spark and to hand lever again, is very liable to mix an inexperienced driver to the extent of pulling the throttle open too wide or of giving the motor too much spark and thus stopping it, or of pushing a lever backward when it should have been pushed forward, and thus obtaining reverse instead of low speed, or some other equally common mistake. Using the hand throttle only, this is very liable to happen, while with the foot throttle it could not; the driver would simply move right hand and right toe to correspond one with the other, both keeping pace with the progress of the machine.

The method of controlling the car by means of the foot throttle or accelerator exclusively is growing in favor rapidly, due to a number of advantages which it has over all other methods of handling the car. By this the car is started in the normal way, then the throttle lever (hand) is set so that the motor will just turn over enough to keep the car in motion—that is, at the point or very close to it which marks the lower limit of engine speed at which the car can be moved.

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time as a few seconds. Try starting the downward pressure a distance away from the hill, and gradually increasing it until the full opening is obtained a short distance up the hill.

**60. In what other way may a hill be taken?** Many drivers like to show the power of their motor by not accelerating until the hill has been reached, when they accelerate gradually all the way up it, so that at the top they are going faster than at the bottom or at any time on the hill. This requires a great deal of excess power, and considerable skill in handling the motor, as well as a knowledge of the motor's ability.

**61. In case it is impossible to learn to hold the foot steady on the accelerator, is there any other way to get the same advantages?** No; unless the driver can master the foot throttle, he must handle his car entirely by means of the spark and throttle levers on the steering wheel.

**62. In adjusting the carburetor from the dashboard, what should the driver try to get?** The best pulling speed; this will not necessarily be the highest speed, nor will it be the lowest by any means. In general, he should adjust to the point of highest speed, then turn back in the direction which produces lower speeds about one or two notches.

**63. In making such adjustments, is it advisable to run on the magneto?** No; when adjusting the carburetor with a dual system of ignition, always run on the batteries.

The spark lever (hand) is then set very far advanced, about midway between the slowest running position and the maximum amount of advance.

The driver then operates the car entirely with his foot, which is kept constantly upon the foot accelerator. By a very slight pressure the engine is supplied with considerable gas and travels slowly along even on high gear. For more speed, more pressure is applied, the amount of foot pressure regulating the car speed at all times. For maximum power and speed the accelerator is pressed down as far as it will go and held there, which is equivalent to a wide-open throttle.

For emergencies, this method is admirable for the removal of the foot, or better the simple lifting of the toe brings the vehicle down almost to a standstill, while an equally quick movement in the operation jumps it from a few miles an hour—say, 8 and 10—to twice or three times that speed in about the length of the car or at most twice its length. When a driver is inclined to travel somewhat slowly at all times, this method is very economical, as the small opening of the hand throttle does not call for much gas, and when a quick movement or speed for a short distance is required the foot accelerator supplies the needed extra gas only so long as it is required.

In such a case as hill climbing, the advantage of this method is apparent. The car is moving along at a pace satisfactory to its driver with no more gas being consumed than is necessary. Approaching a hill, the driver depresses the pedal slightly, just enough to carry the car over the summit of the hill, after which he removes his foot from the accelerator, and the car automatically drops back into the previous slower and economical pace.

At first it is difficult to learn the light, even touch on this pedal which regular operation demands; the beginner will be sure to press upon it too much, giving a greater speed than he wants, or else he unconsciously lifts his toe off of it and the car drops down slower and slower, according to the setting of the hand throttle, until it almost comes to a standstill. Realizing this, he puts his foot on it again, but too strongly. The net result of all this is that the car progresses by jerks, rapidly while he thinks of the accelerator, then slower and slower as he forgets, until the car almost stops, when, thinking of it, a sudden application of the toe brings considerable speed, this being repeated over and over again.

After learning its use, to the point of holding the toe on it with the very lightest pressure unvaryingly for hours, the driver is so charmed with the advantageous results that he will never drive in any other manner. The writer has talked with a large number of drivers on this subject, and not one of them who had ever tried the accelerator method, as outlined above, was willing to drive in any other manner.

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**CARBURETOR ADJUSTMENT** from the dashboard may include a change in the auxiliary air opening or an alteration of the setting of the needle valve which admits the fuel to the vaporizing chamber. Without going into the details of carburetor construction, which will be taken up in its proper place later in the book, the general principle of carburetor

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**64. Why is this better?** At the slower speeds necessary in some part of the adjusting range, the magneto gives such a very poor spark that the normal slow speed is still further reduced by this. The battery, however, always gives a hot spark, no matter how fast or slow the engine runs. Consequently, adjusting on battery ignition has the advantage of furnishing a quick, hot spark while the work is being done.

**65. In general, which is more desirable in a dashboard adjustment of the carburetor—the needle valve or the auxiliary air?** The needle valve is the most valuable to the driver when he knows how to use it right, but is the most dangerous to hand the amateur, as he can put the engine out of commission in so short a time by misusing it.

**66. Is the use of a dash adjustment for the air dangerous?** No; it is impossible to do much more with it than make the engine run too slow or too fast, up to the point in either direction at which it will not run at all.

**67. If an amateur driver has overadjusted his engine in this manner, how can it be remedied?** Simply by turning back in the reverse direction. If he has been running at very high speed, and constantly adjusting to get more speed and more, then the remedy is to turn back in the opposite direction for a considerable distance. Conversely, if he has been attempting to get too slow a speed, and has stopped the engine, give it considerable of a turn in the opposite direction, sufficient at least to allow starting. Then continue

and vaporizer construction is as follows: Fuel flows into a float chamber, the float by suitable mechanism maintaining a lever which insures a constant flow at the nozzle or needle valve. The float does this automatically, and needs no attention. The position of the needle valve controls the amount of gasoline which can flow through the opening, and thus the amount and character of the gas which can be formed. The initial air flow, which picks up and vaporizes the spray of fuel is called the primary air, and this is seldom varied. After this has broken the fine spray of liquid up into still finer particles and converted these into a gas, more air is added to this overrich vapor for the sake of economy and proper combustion.

This is called the auxiliary or secondary air, and is varied from time to time. On some cars there is a rod connecting with the latter adjustment which is carried up to the dashboard with a little handle there and a quadrant to mark and indicate its position. By means of this, the driver is enabled to change the quantity of auxiliary air without leaving the seat by simply bending over and turning this handle.

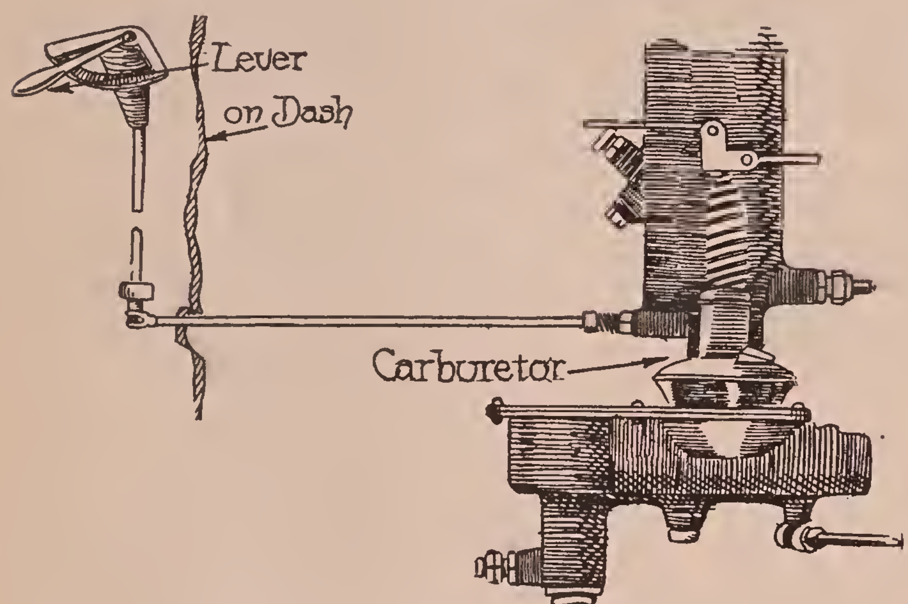

Fig. 16.—Dashboard regulation of the auxiliary air admitted to the carburetor by means of which the motor speed may be varied at will and its general performance improved.

As has been stated, the needle valve or needle controls the amount of fuel flowing into the vaporizer and through its size, shape and adjustment, the fineness of the spray. As the latter more or less governs the completeness of the vaporization process, and by means of this the economy of fuel, and indirectly many internal engine troubles, it is highly important that it be adjusted right. This will vary with a variation in the fuel, with the character of the air and with other items, so on a few cars the carburetor is arranged to have the needle variable up and down, this being accomplished from the dashboard by means of a short finger lever and a rod connection.

Moving the lever turns the needle and thus screws it up or down, according to the direction of motion. This, in turn, gives either more or less fuel, delivered in a more coarse or finer spray, according to the way in which the carburetor is designed and constructed. The utility of this is self-evident when one considers mountain touring, for instance. Suppose a car ascends 5,000 feet or approximately a mile in an hour's running. Obviously the atmospheric conditions are decidedly different at the end of that time than they were at the start. Moreover, while this might be compensated for at the auxiliary air opening, as outlined just previously, the car will require more power, which means more fuel, during the whole climb. By being able to vary the needle, a single change, or rather a series of continuous, very minute changes, could be made which would give perfect

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turning toward higher speed, until the desired point is reached.

**68. Should an adjustment of this kind be used for both high and low speed?** No; for high speed and power only. For low speed, a separate adjustment on the main air or needle valve is desirable.

**69. What is the best carburetor adjustment?** There is no such thing. Every driver wants a different speed or combination of speeds, and the adjustment should be such as to produce this or these. In general, there are three settings: One for high speed regardless of fuel; one for slow speed, designed to give maximum fuel economy, and a compromise between the two, to give a moderate rate of travel with a very good economy of fuel.

**70. Is there such a thing as automatic carburetor adjustment?** Yes; two new devices just placed on the market will do this work automatically. One works on the principle of the rise of fluid in a tube, caused by its heating. This is utilized to move a rod or wire connection which is attached to the auxiliary air valve. The end to which the heat is applied resembles a thermometer, and is placed in the water or exhaust pipes as close to the engine as possible. When the speed rises, the water will heat up more rapidly and attain a higher temperature. Similarly with the exhaust. This heating will cut off some air in the auxiliary air valve and reduce the speed. If the speed goes down too low, the water (or exhaust) will become quite cool and the device will

operating conditions during the long climb. With the air adjustment alone, this would hardly be possible, as a series of decidedly different adjustments would have to be made to insure running alone with no regard for added power, each necessitating stopping the car and raising the hood.

Aside from the lever and rod connections and adjustments for these desirable operating conveniences, there is another method by which they may be controlled or operated, viz., by Bowden wire. This consists of a double wire, the outer being hollow and fixed at both ends, while the inner is the movable portion and is attached to the lever at one end and the part to be moved at the other. Pulling the lever causes the inner wire to move relative to the outer one or skin, and this movement imparts to the part the motion desired.

It has the advantage over rods and levers of being more simple, of being able to turn all kinds of corners or angles, or make any kind of a twist or turn as easily as working in a straight line and at no additional cost. In appearance it resembles any other wire, and is equally as flexible. For carburetor adjustments in particular, it is rapidly coming into favor. In this work, it may be attached to any part of the steering wheel or steering column, or to the fixed fore door or other convenient part of the driver's part of the car.

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**MUFFLER CUTOUTS** are operated generally by means of a button in the floor boards of the front of the car. In this way, a simple pressure with either the toe or heel of either foot, according to its placing, results in cutting out the muffler, so that the engine exhausts into the atmosphere. This is used by many adherents of the old bulb form of signal as a warning to persons ahead of the car's approach. It may be heard where the weak note of the horn cannot, and acts as a notable warning of the vehicle's approach.

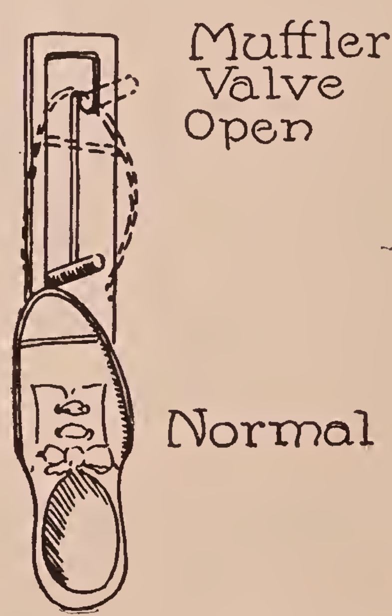


Fig. 17.—One type of muffler cutout bottom, that operated by the top. The other form is depressed like the clutch pedal, and is operated by the heel of either foot.

While this was widely used several years ago, it is now going out of use very rapidly, with the widening use of more strident or raucous horn notes, such as are produced by the various electric horns and a few of the manually operated forms.

Originally it was thought that cutting out the muffler added a great deal to the power of the engine—that is, that the muffler took a considerable portion of the motor's output, and by cutting this out a proportionate gain would be effected. On motorcycles, the total amount of power was, and is, so small that this was worth considering at all times. As a consequence of this belief, the great majority of motorcycle riders and many motor-car drivers made themselves very obnoxious to other riders and to pedestrians by their continuous use of the cutout.

Of late, however, it has been proven that the power loss in properly designed mufflers is very small, but a fraction of what it was supposed to be, so that there

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pull the air valve open and speed up the motor. Thus, within its range of speed, this tends to equalize the motor's speed at all times. The other device is more mechanical, and produces similar results.

**71. Is there any connection between the use of the accelerator, the spark lever, and the dashboard carburetor adjustment?** Between the two former, yes; but between the two latter, no; nor between the first and the last beyond setting the carburetor to deliver the required speed. When the accelerator is depressed to give high speed, it should not be forgotten that this calls for a well-advanced spark as well.

**72. What good is a muffler cutout?** To give notice of the car's approach under circumstances when it is not desirable to use the horn or other warning signal. Also to give the maximum power on hills, in the hardest kind of going, and when trying to attain the highest speed on the level.

**73. Under what circumstances would it be better to use the cutout than the horn?** Generally speaking, teamsters and horse drivers look upon the sounding of a horn as an insult to them, where as it is just as easy to give them notice of your approach by means of the cutout. This is more effective, also, for it conveys an impression of speed, that is a big car coming very rapidly, which the horseman is more likely to heed than he would the horn.

**74. Under what other circumstances is the cutout used?** Many times the driver of car is not sure that some other driver, or either horse or car, is not cognizant of his presence, when such knowledge is desirable from

is less incentive to its use on the score of added power to be gained thereby. A further idea is, that moved to action by the abuse of this habit, many cities and towns passed laws against the use of the cutout, inflicting a punishment for non-observance of the same. This has had the effect of reducing the practice.

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**LUBRICATION TELLTALES,** sometimes called sight feeds, from the fact that the amount of oil feeding is in plain sight, are used on a number of cars. These consist of small glass cylinders, connected into the oiling system of the engine in such a way as to have the same amount of lubricant pass through them as passes to the various parts of the engine and at the same time. Thus, the number of drops of oil a minute to the various bearings is indicated to the driver at all times. As each glass indicates an individual lead to some bearing, cylinder, or other part of the engine, the driver has before him a guide to the lubrication of his motor.

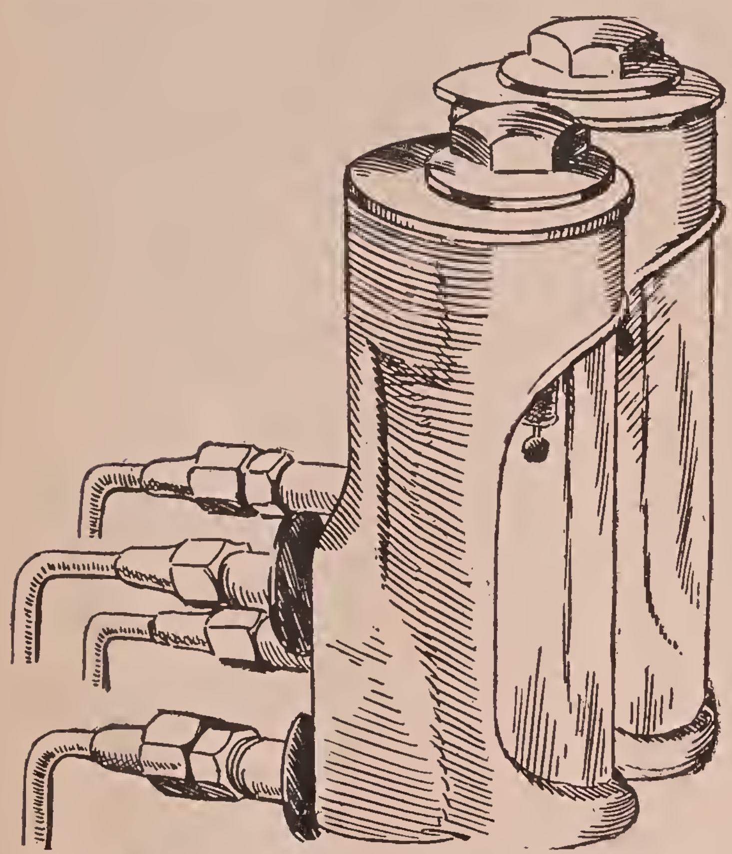

Fig. 18—Lubricator telltale located on the dashboard in front of the driver, which serves to show him how the engine is being lubricated. This is very important and should not be neglected.

These show whether each and every lead has oil flowing through it continuously, and how much. If a lead be obstructed or broken, this would be indicated at once, as nothing would show in that glass. Again if too much oil were flowing, this would be shown by the over-rapid rate at which the drops came in that glass. The driver could note which one showed this condition and adjust the same so as to secure a slower feed. The use of the sight feed, or telltale, then, is not alone a guide to correct and continuous operation of the motor through its proper lubrication, but is also a source of economy in that waste of oil may be reduced to a minimum by its proper use. A third point in this connection is that a considerable portion of cylinder carbonization and consequent misfiring may be prevented by reducing the amount of oil used to a minimum. The telltale on the dash is thus indirectly a preventer of repair bills.

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**SIGNS OF MOTOR HEATING** are many and various, each worthy of immediate attention. In general, an engine will heat through certain forms of incorrect operation, through a lack of adequate water supply, through a leak in the cooling system so that the water is escaping or has escaped, through continuous running at maximum output, and others. The motor should be watched carefully, and at the first sign of serious heating, as distinguished from the ordinary warming up due to regular operation, some thought should be given to the cause of this trouble and its immediate removal.

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the point of view of safety of all concerned. Usually the horn is sounded to mean that the one making the noise wishes to pass, while the cutout noise is not taken in the same way always. Thus, in a city traffic blockade, a driver frequently will open his cutout to let other drivers ahead of or alongside of him know of his presence. In smaller towns, too, where the use of lights is not observed so closely as is necessary in a big city, it is well to travel along with the cutout opened enough to make a noise, but not wide open. This gives a continuous sound, which is a guide and a warning to all other drivers and vehicles, but one which a driver would not care to duplicate with a horn of the electric type as consuming too much current, or with a hand horn as taking too much time and trouble.

**75. Isn't its use forbidden in some cities?** Yes, in a good many; but these laws were brought about mainly by its overuse. When used sensibly and in combination with a good horn, there is little objection to it.

**76. Pressing down on the cutout button brings no response.** This usually depresses one end of a lever, the rising or depression of the other end working a valve in the exhaust pipe. When no sound results with the engine running well, either the lever has become disconnected or the valve has rusted in place. If the latter, pouring kerosene on it will soon free it, after which its fairly continuous use will keep it free.

Serious overheating leads inevitably to one of two things: Seizing of the pistons in the cylinders or of the bearings and pins on the one hand, or to continuous operation under conditions which will bring about a greater amount of damage than seizing. One is bad enough, the other is worse; consequently both should be avoided.

Too rich a fuel mixture will cause heating quicker than will too lean a mixture, although the latter has been known to cause this trouble. Naturally, trouble with the circulating water is a notable and frequent cause of heating; the pump shaft may have sheared off due to some wood or other obstruction in the water; the pump may have become so clogged that not enough water can flow through it to cool the cylinders properly; the size of the pump may be insufficient for the size of the motor (although this is very rare nowadays); the water pipes, either metal or the hose connections, may be too small, either made with too small an interior hole, or a large enough opening may have become constricted in making the connection; if a fan be used with a system which is so scantily designed as to require its constant use, the fan belt may have become loose or may have parted, as well as many other things which contribute directly or indirectly to cylinder heating.

The most noteworthy sign of an overheated engine is steaming at the radiator filling cap, although an unusual amount of heat around the bonnet and front of the car will be noticed quickly. A device has been placed on the market recently which is constructed so as to attach to the radiator cap. In that position, a bright-colored fluid indicates in a more or less rough manner the temperature of the water within. Since the temperature of the cooling water is a certain guide to correct or incorrect heating, this gives a close check upon this point and one which is apparent at a glance.

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**UNNECESSARY NOISE** is somewhat of a guide in the correct operation of the car, for the modern machine is more or less noiseless and is becoming more and more quiet each year with each new design, in fact. Excepting those very old cars which date back to the period when noise was accepted generally as a more or less necessary evil, and those later cars which have had considerable neglect and abuse, noise is unnecessary and avoidable; continuous noise anywhere on the car means that something is wrong and should have attention before driving the machine much farther.

There are and always will be the small and unimportant noises, like the faint squeak when a glued wood joint is strained, the faint singing brought out when a very thin sheet-metal part is made to vibrate considerably, and other similar ones. These the novice should learn as quickly as possible, as well as the steady purr of his engine when firing properly and continuously, and the regular hum of well-cut gears meshing properly. Knowing these, the operator can detect any other noises at once and be in a position to say to himself: "What's the matter now? I hear a noise in the rear axle" (or wherever it may be).

A very common source of noise, and one which just goes to prove the statement previously made, is that emanating from the valve lifts, push rods, or valve

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**77. Is there any device for indicating the heating of the motor?** Yes, a little device placed on the market in 1913 screws into the radiator cap and indicates the temperature of the water therein, much as a thermometer would.

**78. If you were using such a device, and it indicated that the water was too hot, what would you do?** Stop at the very first opportunity and put more water, and cold water, into the system. Usually heating is a sign that the water has been allowed to get too low, as modern cooling systems are more than adequate.

**79. In a case of this sort, are there any precautions to be observed?** In taking off the filler cap, be careful not to loosen the final turn of the threads necessary to free it, with the hands on it. Otherwise, if the water inside is at or above the boiling point, there will be steam and some pressure in the radiator. When the cap is loosened, the pressure will blow it off, and the steam will burn the hands and face.

**80. How can this be avoided?** Loosen the cap down to the last turn. Then take a long-handled pair of pliers, wrap the hands holding them with a thick cloth, and finish unscrewing and removing it. Be careful, however, to lift it off very quickly.

**81. When the filler has been removed, suppose no pail is available. In a case of this sort, use a cap or hat, or take a section of old inner tube, and tie the end up so as to make a kind of long trough.** This will hold a great deal. A big grease gun is good, if clean. Sometimes a can holding oil or grease can be emptied, then wiped as clean as pos-

tappets as they are variously called; namely, the parts which are moved upward by the cams on the camshaft, and in turn lift the valves so that the carbureted gas may enter or the burned gases leave the cylinder. As shown in Fig. 15, there is too much space between the tappet and the bottom of the valve stem, due to wear, a lack of adjustment, incorrect proportions in the first place, or other causes.

At every turn of the shaft, the tappet is lifted by the cam more or less quickly. Normally, it would rise but a very short distance before meeting the tappet, which would then rise with it. In the condition shown, it will rise the entire distance of the space between the two parts, and at that point will be moving much more rapidly than at the beginning of its travel. The result is that instead of picking up the valve stem quietly and gradually, it is slammed up against it with considerable force. This regularly repeated blow cannot help but make a great deal of noise, in addition to which it wears both parts much more rapidly than there is any need for doing.

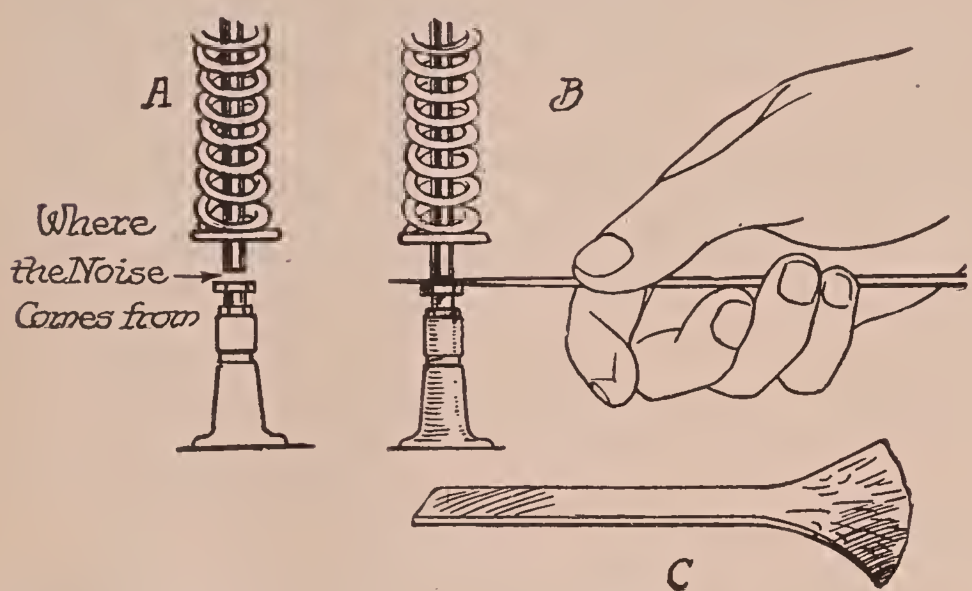


Fig. 19—What causes noise in the valve tappets, how it may be ascertained and consequently, remedied.

It is obvious, also, that the valve does not lift as much as the tappet by just the amount of clearance between the two —that is, it has a smaller lift by this amount. This means that the cylinders are not getting as much gas as they could and should by the amount which this cuts off of the valve opening, while at the time of exhausting the burned gases are not as thoroughly expelled by just the same amount.

In the instance cited then, the poorly adjusted valve tappet causes not alone unnecessary noise, but it also contributes to lack of power through smaller charges and poorer exhausting, and, furthermore, it brings about more rapid wear of the parts.

There is the case, however, of the old car which is so far gone as not to warrant any changes which cost much money or the old form which, while not as far gone as this, is still so designed and constructed as not to warrant anything new being placed on it. Even with these cars, a lack of noise is as desirable as on more later and more valuable cars; hence, any method of diminishing the noise which is unavoidable would be welcomed by the owners of that form of machine.

In some cases, the construction of the motor and its parts will allow of fitting a large removable plate, extending the entire length of the motor, and covering all of the valve actions. Where this can be done it has the merit of few parts—simplicity, cleanliness, and good apearance—in addition to reducing the audible noises. If this cannot be done, either, a good substitute is shown in Fig. 20.

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sible and used. Lacking every other method, the underpan can be removed from beneath the engine; it will be large enough to fill the radiator at one trip.

**82. Suppose the motor is very hot and the water is not very cool.** In that case, it is best to drain off the remaining water, which will be very hot and will help heat up any fresh water put in. After doing this, let the engine stand empty for a few moments in order that it may cool down somewhat. Then put in just a little water at a time, as adding a lot to a very hot engine may cause a sudden expansion which will crack a cylinder or water jacket.

**83. If it should happen that the motor is exceedingly hot, this method may not be sufficient.** Then draw off the water you have just put in, and repeat the process several times, until the metal of the cylinders has become thoroughly cooled, so that it will no longer heat up the water as you put it in.

**84. A hissing noise comes from under the hood, somewhere on the top of the engine.** This probably is a pet cock which has been left open in priming the engine, or at some other time.

**85. Pet cocks are all closed tight, but hissing sound continues when the engine is running.** Spark plug may be broken or loose, so as to permit escape of compressed gases, which causes the hissing.

**86. All spark plugs are all right and tight in the cylinder heads, but hissing continues.** It

It consists of a piece of rubber tubing fitted around the tappet and valve spring, and fastened there. When properly attached, it will reduce the valve noises to a minimum. With a motor such as is shown in the sketch, it is an easy matter to fit this device. The tubing should be larger than the largest diameter of the valve spring by a very small amount, just sufficient for clearance, as a very large size makes the appearance of the completed muffler so bulky and bulging as to spoil any attempt at neatness or simplicity.

The tube is cut as shown in the separate sketch at the right, after which it is sprung around the parts and drawn together. Next, the ends, where there doubtless will be a circular member, are wound with wire or tape, drawing the balance of the piece together in so doing. It is not desirable or advisable to wire or tape the entire length, as it often is necessary to take these off to get at the valve motion, in which case removal is considerable of a task.

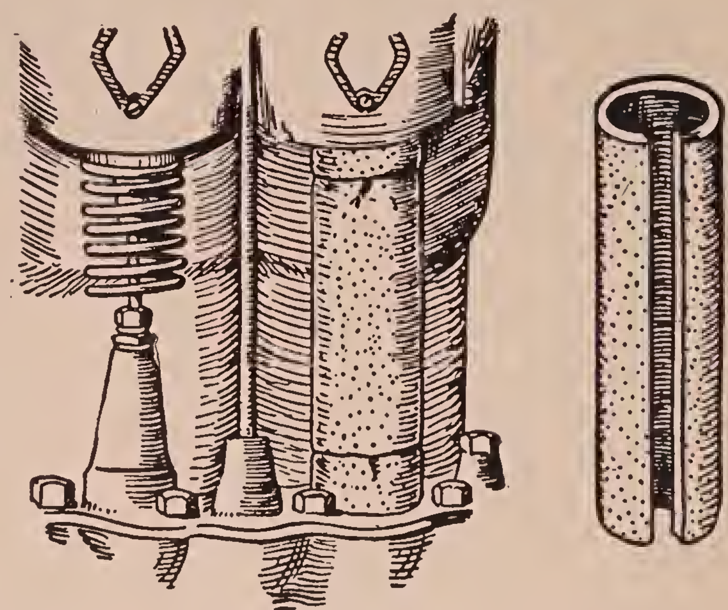

Fig. 20—Simple method of enclosing the valve mechanism on old cars so as to reduce or eliminate all of their noise.

The same is true of almost any other lack of adjustment; it gives an outward sign to the driver in the way of unnecessary noise. In the efficient and economical operation of the car, every needless noise indicates some loss and something in the way of unusually rapid wear. It is apparent, then, that a novice driver very early in his career should learn to distinguish all of the regular and necessary noises, so as to be able to discover in a moment any unnecessary and irregular noises, which mean time, trouble and expense.

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**LACK OF REGULAR OPERATION,** of course, calls for immediate attention, but many new drivers think that some forms of irregular operation have a perfectly natural cause and hence do not amount to much, at least not enough to be worthy of serious consideration. Such is not the case; every noticeable irregularity of operation indicates something which is out of order and should be corrected before further running.

Among these a few may be pointed out. Thus the engine may fire or give an explosion regularly in each one of the cylinders, and then for some reason miss an explosion or fail to give an explosion in some one cylinder for a considerable length of time. This means that something is wrong with that cylinder; the ignition should be inspected first. A good way to try this is to unscrew the spark plug, and laying it on top of the cylinder so that a metal part of the plug contacts with the metal of the cylinder, crank the engine over a few times with the gas shut off. The ignition being left on, a spark will occur in the various cylinders in their regular order. When it comes to the suspected member, the spark plug

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may be due to a loose valve cap or a blow hole in a cap which has just opened up. Try and locate the cylinder from which it comes. When this is done, slow the engine down to the minimum possible speed, then pour gasoline over the valve cap which is suspected. If it has a hole or crack in it, the engine will speed up caused by the fuel leaking in.

**87. All valve caps are found to be tight, but the hiss continues.** It has a deep sound, and seems to come from inside the cylinders. This is caused by defective piston rings or scored cylinder walls, which allow the gas during compression to escape by the piston rings. The pistons must be taken out and new rings fitted, or if the cylinder walls are found in bad shape, they must be reground. If this is very bad, requiring that much metal be taken off, it will mean also new piston rings and possibly a new piston.

**88. A light clicking sound comes from the valve side of the engine.** It is regular and continuous. If the valve is made up—that is, has the head fastened to the stem instead of made integral with it—one of the valve heads may have worked loose.

**89. Valves are made in one piece, clicking continues.** One of the valves must be loose in its guide, so that when it rises it strikes one side, then when it comes down it strikes the other.

**90. Valves fit guides perfectly, there is no looseness or wear perceptible, clicking continues.** If it is not the valves, stems or

for which is laid out on top in plain view, the spark may be seen plainly if one occurs, or the lack of it noticed if there is no action there. If no spark is forthcoming, there must be a reason why, and close application will find this. If, on the other hand, a spark does occur regularly and consistently, then another cylinder must be at fault.

Another form of intermittent action which the novice is likely to think usual and perfectly correct, but which is not, is that resulting from a clutch which is beginning to slip. As has been explained previously, the function of the clutch is to connect engine and transmission when a connection is desired, and to separate them when this is required. In general, clutches are held into action—that is, connecting engine and transmission—by means of springs. When these are poorly or unevenly adjusted, or when they have become worn or weak they do not hold as firmly as they should. At such a time the vehicle does not progress or else it moves forward by jerks.

When the clutch takes hold, it moves forward, when this member slips it stands still. In this latter case, the engine may be turning at a furious rate, while the driver cannot understand why his car does not progress. In many such cases, if the springs alone are at fault, a few turns of a screwdriver or wrench will make the matter right, and the car will move along as well as could be asked.

There is, however, the additional possibility that the surface or lining of the clutch may be worn, the slipping coming on these worn spots, or the surface may be only greasy, the slip coming when the grease is reached. In the last-named case, a little powder may be dusted onto the surface to absorb the grease or at least neutralize its action and no further trouble result. If the lining be worn, however, the driver can do nothing beyond tightening the springs up to a point where the clutch will hold continuously and get home with this arrangement, after which he proceeds to put on a new and perfect lining to replace the old worn one.

When the water-cooling system has heated up to the point where the engine is about to seize, it will run intermittently—that is, it will run properly for a time, then seize partly—but before the engine actually stops will release and allow it to continue. In short, the heating of the cylinder walls and piston has reached a point where even smooth and continuous running is not possible, and it manifests this condition by almost stopping every now and then. To relieve this condition, the driver should stop at the first supply of water, draw off what little very hot liquid the system contains and fill up to the limit of capacity with fresh cold water.

In a case where this condition can be detected beyond any doubt, it is an excellent plan before running the motor again, even with a full supply of cold water, to introduce a little kerosene or other very thin lubricant into the cylinders above the pistons. This may be done by taking off a spark plug, valve cap, or other member which will give access to compression chamber, and pouring the lubricant in at that point. The object of this is to lubricate the hot and dry walls of the cylinder and piston before the two are moved across one another. If this be not done, there is the possibility of the sudden introduction of the cold water

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guides, it must be farther down in the valve operating system, as in the valve operating plunger or its guide, or, if not there, still farther down in the cams.

**91. In the operation of the car, a dull whirring sound is heard when the car is going fast but not at slow speeds.** This may be the speedometer drive gears. Frequently the noise which these make meshing with each other is not noticed until the car is sent along at a fast pace, when it becomes very apparent.

**92. How can this be remedied?** Sometimes moving the gears apart a very slight amount will help. The application of a heavy grease or graphite does some good. Try both.

**93. If the engine won't start, what should be done first?** Look for fuel in the tank. No engine will run without it. Next find out if it is reaching the carburetor. Then be reasonably sure that the gas made there gets into the cylinder. A piece of waste unconsciously left in an inlet pipe will cause a world of trouble.

**94. If the fuel system is right throughout, gas in tank, free flow to carburetor, good gas produced and getting into cylinders, and still the car won't start.** Try the battery system for a spark at each plug. If a battery tester is available, use it; if not, lay the plugs out on the cylinder heads so the points are visible. Then turn the engine over slowly,

causing the jackets to shrink quickly and thus take hold of the pistons before the latter have had any chance to cool off. If both are dry or without lubricant between them, this is more than possible; it is quite probable.

Another form of intermittent operation is brought about by operating the car at very slow speeds and may not be noticeable at higher rates. This is produced by a considerable amount of wear in the universal joints between engine and rear axle. Considering a car with two of these, there are four possible points where the wear may be considerable. Granting a large amount of wear at all four, when the car is operated very slowly, so that at times it drives the motor through its weight and momentum, while at all other times the motor is driving the car, there is a reversal of direction of drive. At each such reversal, the total amount of wear in the joints is taken up. For this reason there will be a noticeable lag in the movements of the car; first, when there is a change from the motor providing the forward impulse to the car as a source of movement, and second, when the reverse change is made. That is, at every reversal of power, including as well the use of the reverse gear in the transmission, all of this wear with its consequent lost motion must be taken up before there is any movement of the car. Repeated several times, this is likely to puzzle even an experienced driver, for so soon as more power is used or greater speed brought about, the trouble disappears; it is apparent only at slowest speeds, when the time taken up in absorbing this lost motion is appreciable. At other times, changes of speed would not have any noticeable result of this kind, and the lag would be of so very short duration as compared with the speed of all other movements as not to be noticeable.

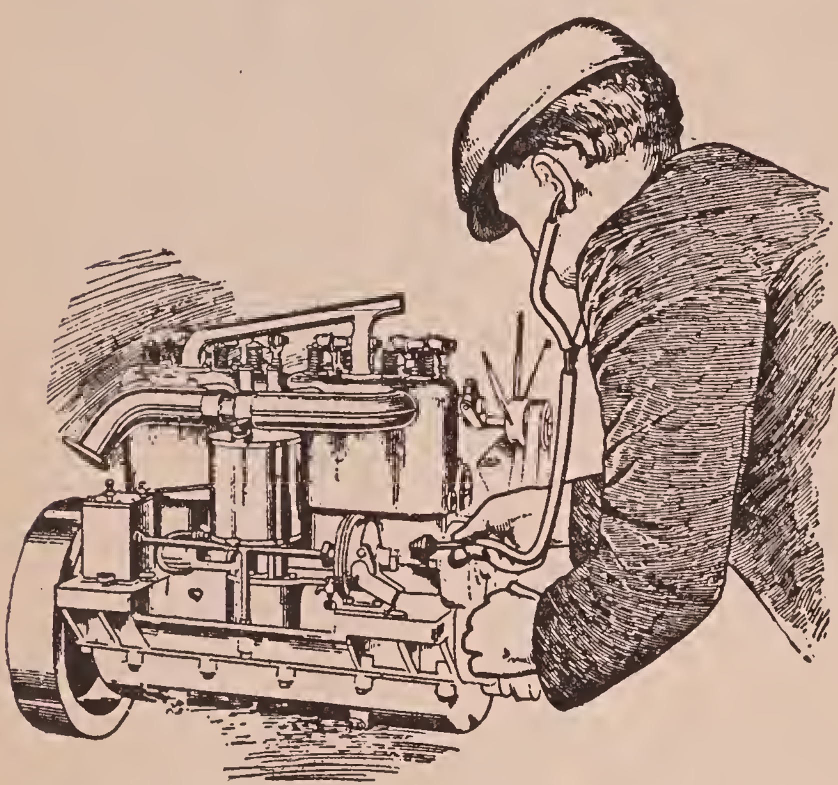

Fig. 21—Using the stethoscope to find out the source of unusual or peculiar noises in the motor, an excellent preventative of trouble.

There are, of course, other forms of trouble which will produce intermittent action of the car or engine—that is, will bring about a lack of regular and continuous operation. In general, anything which has this effect is wrong in principle, and should be investigated. In so far as motor operation is concerned, any instrument which will indicate regular and systematic operation, or the lack of it, is a great help to beginner and expert alike. For this purpose, a modification of the stethoscope used by physicians is very handy, since it magnifies and makes more clear internal noises. In Fig. 21 a driver is shown listening to the operation of his engine with one of these devices.

By placing this first on one bearing and then on the next, any abnormal noises or any unusual action will be made apparent at once, without waiting for

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watching for the spark. If all four spark in the open air, they are fairly certain to do so within the cylinder.

**95. Motor hard to start, but by continued cranking one or two cylinders will fire.** Batteries must be too weak to give a good hot spark all around. Try them. If gone, turn over to magneto and try to start on that, remember that it must be cranked more quickly. A good plan is to shut the ignition off, open the gas wide, then wind the engine over quite a few turns, in order to fill the cylinders up with good gas. Then turn on the magneto, and pull her over one short, sharp, and very quick turn.

**96. There is plenty of gas and a good spark, but the gas does not seem to ignite.** Lack of compression. This can be proven by opening the compression cocks and pulling the engine over with them open, then closing and pulling her over again. There should be a great deal of difference. If not, compression is too weak to produce a mixture which will start.

**97. What is the remedy for this?** Many times this is caused by gumming up of the piston rings through using too thick an oil, or one which is unsuitable to the motor in some other way. Open all cocks and pour in kerosene or denatured alcohol. The former will cut out gummed rings in from one-half to one hour. The latter will do a more thorough job and remove all combustion head carbon as well, but requires at least 8 hours.

the trouble which it is sure to bring, to show it up. After the bearings, all surfaces where parts slide over one another, as in the case of cylinder walls, etc., can be tested in the same manner. In this way the entire car can be gone over and any departure from regular and systematic action detected at once before there is any trouble or before anything can happen which will cause considerable expense and lose to the owner the use of his car for some time.

## STARTING, AND ITS ATTENDANT OPERATIONS,

are likely to frighten the beginner, for much has been said in the past few years about the dangers of cranking, etc. The rapid progress which has been made in starting devices in the past two years has made any fear of this operation, insofar as new cars are concerned, groundless. On the older makes, however, and the machines which are sold at a very modest price, the engine must in many cases be started by hand.

If a few simple instructions be followed, this need not entail any hardships, for it is a simple operation. In general, without going into the construction or operation of the motor, it becomes necessary to swing the crankshaft and with it the flywheel and the various connecting rods and their pistons over so that in the cylinder, which is ready to fire, the piston shall pass the upper dead center and be descending before the spark occurs. If this be done, the spark explodes the charge, and, since the piston has passed the upper center and is descending, the explosion drives it downward, and it continues to turn in that direction in which it has been started.

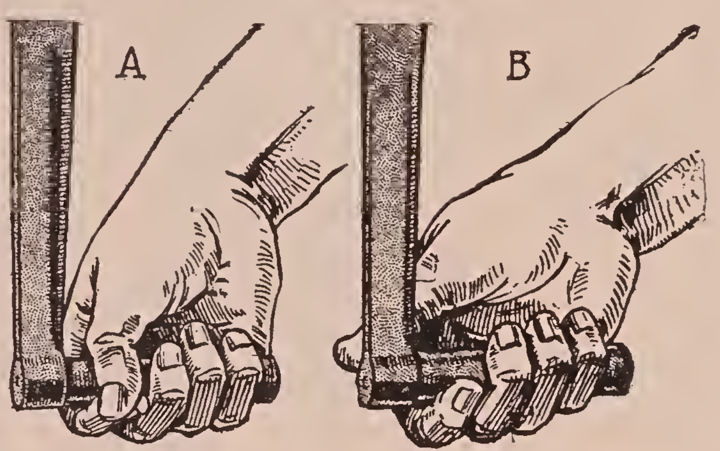

Fig. 22—The two methods of holding the starting crank, at the left; A shows the wrong way, with the thumb around the handle. At the right, B indicates the proper and safe method.

If, on the other hand, the crank be turned so slowly that the piston has not reached the dead center when the spark comes, then the explosion will throw it backward—that is, in the opposite direction to which it is being turned by hand—and it will continue to run backward. Movement in this direction is useless, since with it the car cannot be propelled forward as desired; but the more important point lies in the opportunity of injury to the person cranking.

Since the crankshaft normally turns toward the right or clockwise, the starting crank is so constructed that it connects with the shaft only when turned in that direction and with the motor shaft lagging or dragging behind it. To effect this, it is necessary to construct the crank with a lip or projecting part which connects with a similar one on the crankshaft. When the person cranking has made an effort to throw the engine over dead center for the initial start, a slight pull toward himself will draw the starting handle out of mesh with the engine shaft. If this be not done, and the engine starts, its continuous running will throw the crank out. In this way, the operator will receive no harm, even if he

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**64A. In using the accelerator pedal, which is between the clutch on the left and the brake on the right, one foot must be taken off of either of the others. Which plan is best?** It is safest to take the right foot off the brake, as there is little occasion to use this when speeding up, which is the only reason for using the accelerator. This leaves the left foot on the clutch and if danger arises, the right foot may be lifted off the accelerator and moved onto the brake quite quickly, while at the same time the left foot presses out the clutch and stops the application of power.

**65A. Is there a better plan than this?** Motorists generally consider the arrangement by which the accelerator is placed beyond the other two, at the left on a right drive car and at the right on a left-driven machine, is superior to placing it between the others. There is another method affected by some makers of making it a heel-operated pedal, placed in line with one of the others, but this has not found favor, being more difficult to learn and use. Incidentally, it is a poor plan, because neither of the major pedals will ever be used in combination with it. That is, when the accelerator is in use, neither of the others are; when the others are in use, either one or both, the accelerator is not.

**66A. Is it advisable to change carburetor adjustment frequently?** No, on the contrary, it is decidedly inadvisable. The ordinary American car does a considerable amount of slow speed work in the cities and an

does not lean backward, but continues to hold the crank in mesh with the shaft.

This disengagement is brought about by the shape of the meshing faces of the two parts, which shape similarly prevents disengagement when the engine starts to run in the opposite or wrong direction. In that case, the engine shaft takes a firm hold on the starting handle and carries the same along with it. If the person who is cranking it has retained a hold on it, and it seldom is possible to crank an ordinary motor without continuing a more or less firm grip on it, this reverse movement will come against the person's hand and arm, and, unless able to let go quickly, great injury will be done.

**BACKFIRING.** When an engine fires too quickly in this manner—and it may be due as much to an improper setting of the spark lever as to the slow motion of cranking—this is called backfiring. When an engine backfires, the person who cranks it invariably receives a severe blow on hand, wrist, or arm. There are several ways in which the driver can protect himself against this. The first, which is not so easily learned and has never become as popular, is that of cranking left handed. When the left hand is used, the pulling-up process must be done in such a way that, should the motor backfire, the blow will come upon the flexed arm and upon the hand in such a position as to make opening the fingers an easy matter.

Left-hand cranking, then, has the double advantage that the arm is flexed and thus receives and absorbs the blow without doing any damage, and also the fingers may be opened and the crank allowed to slip out of them so that no further blows are sustained. This is made possible by the thumb being on the upper side so that the crank handle does not work against it but against the fingers, which are much more flexible.

This lack of flexibility of the thumb, as compared with the fingers, gives the clue to the second method of cranking and the one which has been adopted most widely. This is pictured in Fig. 22, which shows that in cranking with the right hand, the thumb should be folded back, and not wrapped around the handle, as in the grip assumed on a baseball bat or other round object. When this is done, the crank is drawn upward by means of the fingers only, and if a backfire occurs, these can be opened to let the crank rotate harmlessly. After it has been learned, it is as easy to crank in this manner as formerly when the thumb was wrapped around the handle.

In the construction of engines, however, a point has been reached now where the majority of them will start on the spark, as it is termed, about every other time. In stopping the engine, when it has been running, the spark is shut off but the gas or throttle is left on. In this way the cylinders are left filled with gas, all ready for restarting. When it is desired to start again, the spark is thrown on, and by moving it slightly it usually is possible to produce a spark in the cylinder which is nearest ready for the explosion. If the cylinder is already full of combustible gas and a spark is produced in it, an explosion will result and the engine will start to run. This is called starting from the seat or starting on the spark, and some drivers become so expert in manipulating their levers at stopping and starting as to produce this desired result almost every time.

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equal amount of fast work in the country, being compelled to change from the one to the other at a moment's notice. This requires a kind of general adjustment. It is impossible when constantly changing in this way to get the best effect of either by changing the carburetor adjustment. If the factory setting gives good all-around results, do not monkey with it unless you feel capable of adjusting it to give better results.

**67A. Can a carburetor be set to give maximum fuel economy and the best speed or greatest power at the same time?** No, the two things are contradictory. A driver can have but one of them. He must choose speed and power regardless of fuel consumption, or economy with the highest speed cut off.

**68A. What causes the motor to heat the quickest and consequently should be avoided most carefully?** A lack of lubricant will cause the engine to heat with great rapidity, and as soon as the old oil present on the cylinder and piston walls, as a thin film, has burned off, the parts will soon expand and the pistons will seize.

**69A. Next to a lack of lubricant, what causes a motor to heat most quickly?** Too rich a fuel mixture.

**70A. How is this overheating noticed?** The motor runs hard, giving out a harsh metallic sound and steam issues from the radiator cap. In adition, heat waves may be noted coming up from all parts of the hood.

**STARTING DEVICES.**

A large number of the modern starters, notably those of the gas and acetylene type, are based upon this action. The principle of these devices is to introduce into the cylinder which is ready a charge of explosive gas by means of a hand or other pump and a special vaporizer. This done, the spark is produced as outlined above, and the motor starts. The idea is to substitute the certain introduction of a charge which is known to be combustible and into the cylinder which is certain to be ready, for the more or less uncertain method of leaving the gas on when stopping and hoping that a proper charge of gas will be drawn into all cylinders and that this will remain there until the driver wants to start again.

For rendering starting easy there are a number of devices which are known as primers. The function of these is to introduce into the cylinders at starting time a fresh and certain charge, rich enough in fuel to be combustible beyond any question of doubt. The simplest way in which this may be done is by keeping under the seat or wherever it is handy, a small oil can filled with gasoline. By opening the valve caps or loosening spark plugs, a little of this may be squirted into each cylinder, and, being accompanied by little air, is sure to vaporize into a very rich mixture, which is almost certain to start at the first spark.

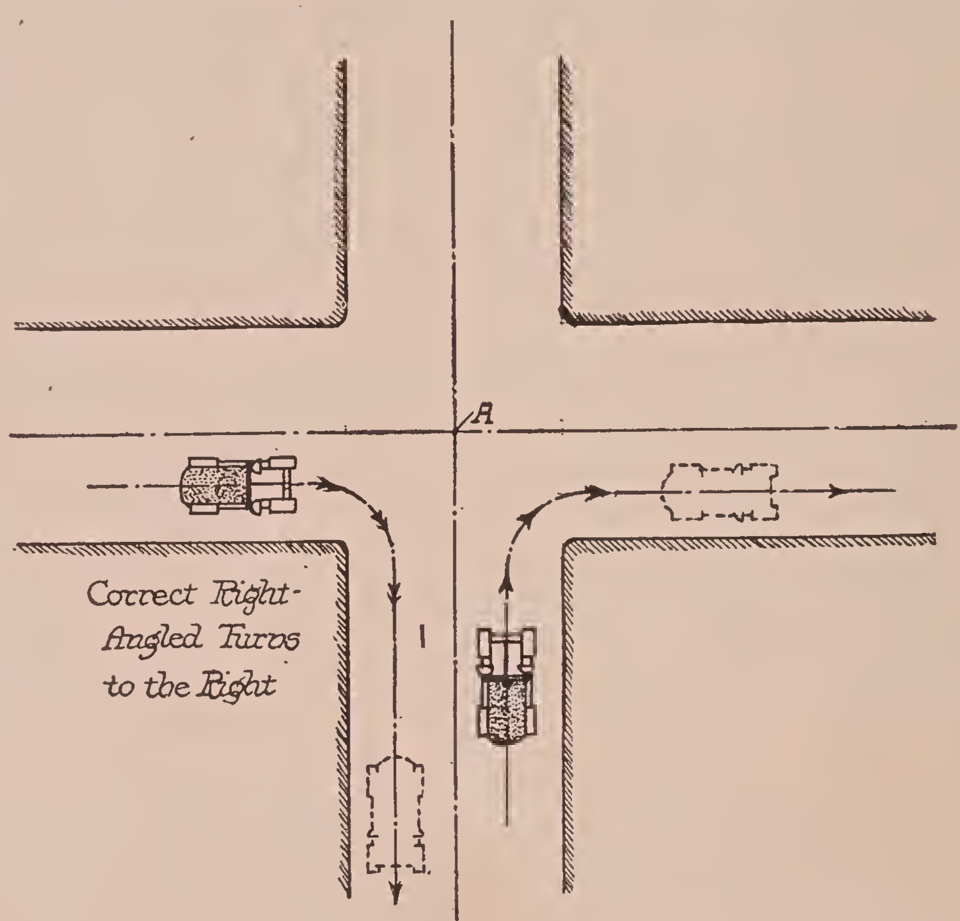

Fig. 23.—The proper and safe method of making a right-angled turn to the right, namely, close to the curb or roadside.

An elaboration of this is the form carried on the dashboard in which a simple pressure of toe or hand forces fuel through separate pipes to all cylinders without loosening anything. Naturally, this is more expensive than the 10-cent oil can, and it requires considerable piping, which makes the engine appear complicated. A recent device, which has the double advantage of simplicity and low cost is a spark plug which is made with a passage on the side not unlike a priming cup, as these have come to be called. This passage is controlled by means of a movable handle, so that by simply turning it an opening into the combustion chamber is available.

This saves loosening up the spark plug or other parts, besides saving a great deal of time. When these are used, priming is a simple matter of turning the handle, squirting gasoline into each, and closing them again.

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**71A. What is a piston slap?** This is a noise seeming to come from within the cylinders, but which cannot be traced to any one or any particular place.

**72A. In that case, how can it be located?** By means of a stethoscope or other means of transmitting the internal noises of the engine to some sensitive part of the body. Some expert engine tuners can get the same results by holding one end of a long metal rod between their teeth, and placing the other end on the various suspected parts of the engine.

**73A. What causes a piston slap?** Experts disagree on this, but it is generally thought to be caused by a piston which is loose on its pin so that it proceeds upwards until it meets considerable resistance and then is forced down sharply. Similarly, it is forced down readily until a suction above draws it back by the amount of wear in the piston pin hole. Another explanation is that a ring may be loose in its groove in a vertical direction, and bring about noises in the same manner as described for a loose piston. Another explanation is that the piston is too loose in the cylinder and sets in it at a slight angle, until pressure against it as on the compression and explosion strokes, suddenly forces it to straighten up.

**74A. How can it be remedied?** It is best to put on new piston rings, and if that does

**GENERAL DRIVING RULES**

are many and varied. What holds true of city work does not apply when conditions on country roads are considered. So generally is this recognized that in all States where speeds are specified in the automobile laws a wide distinction is made between the permissible rate in the city and that in the country. Aside from keeping within the legal and correct rate at all times, the driver will do well to consider his own safety and that of his passengers at all times, to say nothing of the possibilities in the way of injuries to pedestrians, particularly young children, who in the cities must use the streets for a playground.

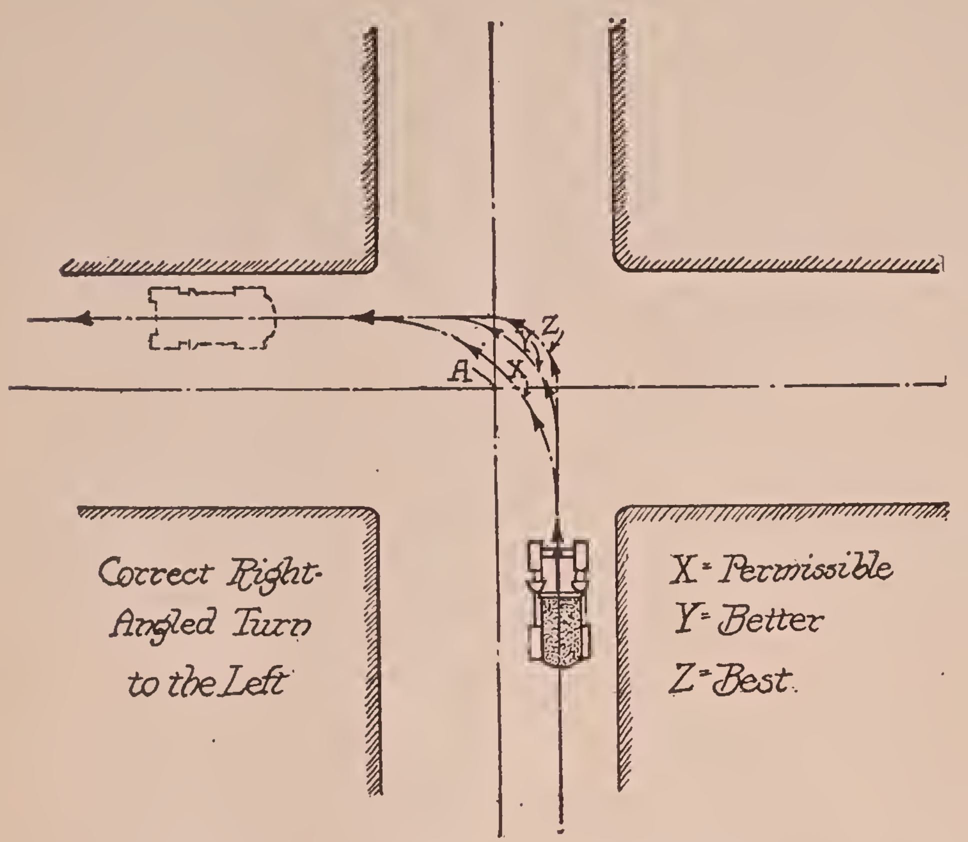


Fig. 24—The best method of making a right-angled turn to the left, showing at X, a permissible way, at Y, a better one, and at Z, the best plan.

In the larger cities, this condition is common, and drivers who have a real regard for their personal safety and that of others should drive very slowly and cautiously through neighborhoods and sections of the city where there are many children. He cannot tell at what moment a boy, chasing a baseball, football or other plaything, may dart across what seemed a moment before like a clear street, this movement bringing him directly across the path of the swiftly moving vehicle.

In general, driving has few rules which are universal. In this country, all traffic follows the rule of keeping to the right and of passing vehicles ahead and moving in the same direction to the left. Motorists always should offer assistance to another driver who appears to be stalled. In making turns, the driver should signal to those behind by extending his right arm as far as possible, so that this may be seen in the rear, even if the top be raised. If this is a turn to the right, the curb or edge of the road should be hugged as closely as possible, for the double reason of safety to those behind on the first road or street, and for the sake of safety in not bringing the car too close to the center of the second road or street.

When a wide turn is made at a right-angled corner, there is the possibility that another vehicle may approach moving in the opposite direction, before the driver can get back to the right side of the road on which he belongs. The proper way in which to make a turn of this sort is shown in Fig. 23, while the next sketch, Fig. 24, shows a correct turn to the left. In the latter case, the driver

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not stop the noise, a new piston, or at least have the piston pin and its hole in the piston inspected for possible wear. On some motors, it can not be removed.

**75A. What does a sharp whistling noise indicate?** The escape of gas under pressure. Such a case would mean a defective gasket or packing for some part of the inlet or exhaust pipes.

**76A. How can this be determined accurately?** By listening closely, it will be noted whether it comes during a suction or an exhaust stroke. In addition, if the exhaust either fumes or an odor will be more or less noticeable. When the offending pipe has been located, it is a simple matter to go over all its joints and packings, until the bad one is found.

**77A. A loud knocking comes from the engine?** This generally indicates a loose connecting rod.

**78A. How can it be stopped?** By tightening up the rod in question or if it seems well distributed and occurs fairly regularly, it may be that all rods are loose. These should be tightened quickly, after the trouble is ascertained, as a great deal of damage can be done in a few moments by loose connecting rods.

**79A. Could one come loose entirely?** Yes, this is possible and quite probable with some types of big end fastenings. When it happens, the flying rod end usually wrecks

should make a complete detour around an imaginary center of the intersection, marked *A*. This is the point where the center line of the two streets would meet if actually drawn, and represents the first point at which the motorist can pass from the correct right side of the one street to the correct right side of the other; in short, it is the legal turning point.

When the reverse turn is made at a corner—that is, the complete reverse from traveling north on one side to moving south on the other—the motorist should

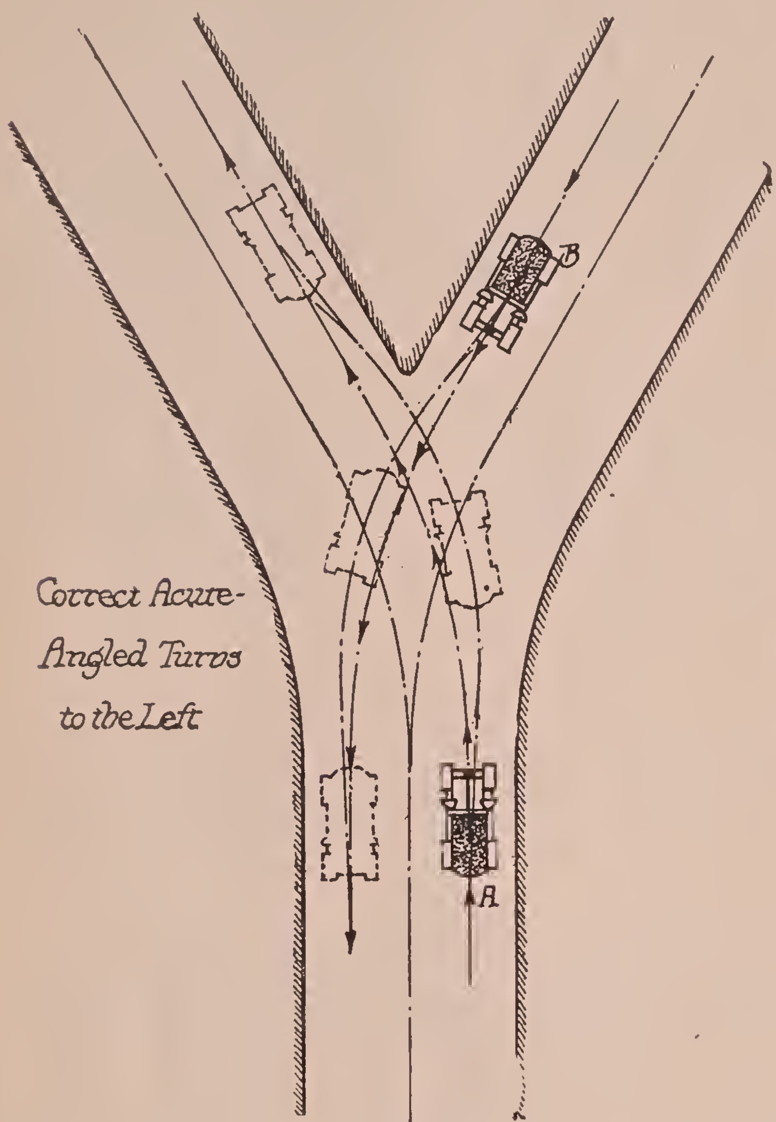


Fig. 25—The correct method of making an acute angled turn to the left, showing in dotted lines the manner in which another car may be given as much leeway as possible.

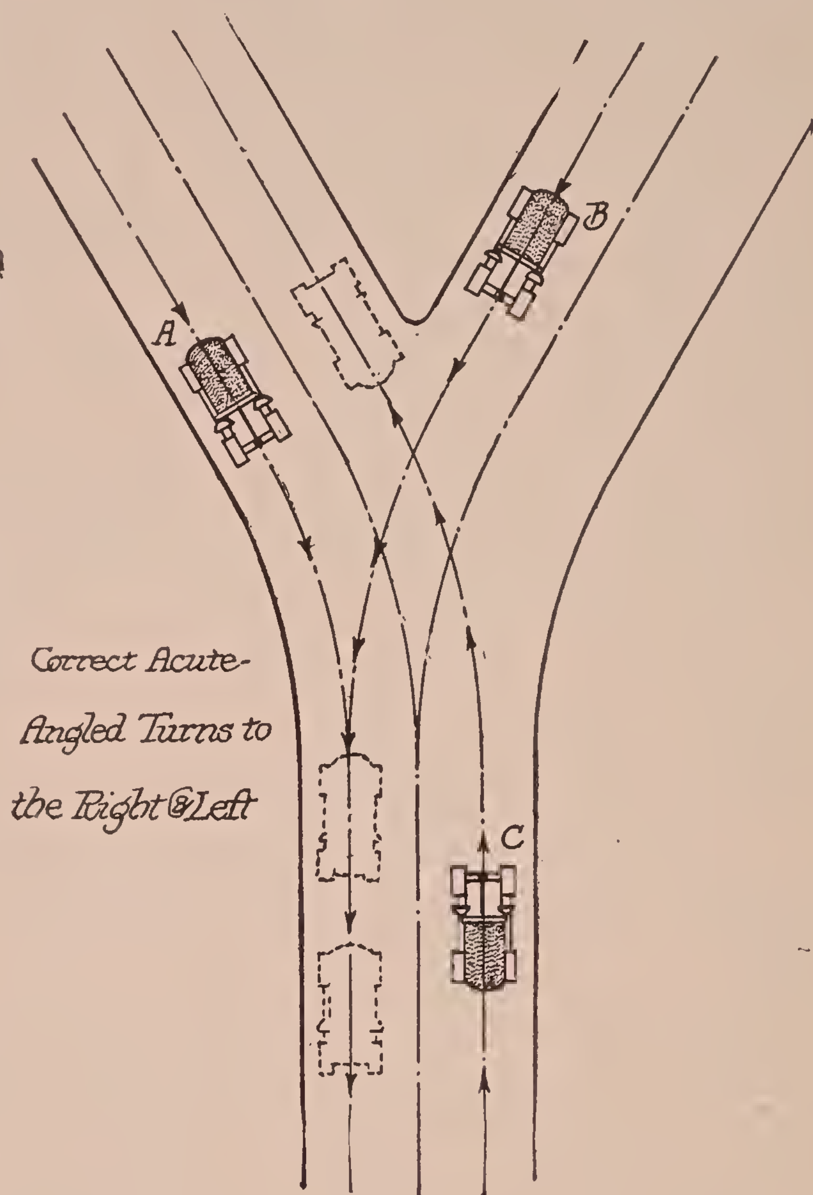


Fig. 26—The correct method of making an acute angled turn to either right or left when other cars must be considered. Here A has the right of way down, followed by B. Unless C is moving very fast, B will get out of his way so that he will have no trouble.

round this same point, because at any other part of the crossing he would be in the path of other vehicles, and consequently liable to damage.

At crossings which are not at right angles, many peculiar accidents occur. No set rules can be given for these beyond advising each motorist to act along the lines of greatest safety at all times. Thus at a diagonal crossing, such as is shown in Fig. 25, the motorist at *A* would depend upon the rate of speed at which he was moving relative to the approach of *B* and their two positions relative to the line of intersection, as to whether he would attempt to cross in front of him or give him (*B*) the right of way. From a similar standpoint, *B* would have to be governed by the speed and position of his opponent *A's* car.

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the crankcase, and often the cylinders and other parts with it.

**80A. If the starting handle flies back, on trying to start?** The spark lever is advanced too far, and is in such a position that the motor will backfire, and possibly run backwards.

**81A. What different does this make?** It is dangerous to the person trying to start the engine, because the crank is so constructed that it catches when engine pressure is exerted in a backward direction. This means that if the motor runs backwards, the crank will turn with it until freed by some external means.

**82A. Why should the operator care or worry about this?** In backfiring and continuing to turn, the operator's danger comes in the first sudden backward movement, when he is pressing forward on the crank. This has been the cause of more broken arms and wrists than any other one thing.

In general, either one could swerve slightly for the sake of safety, in case the other showed no disposition to give a fair share of the road. This possibility is shown by the dotted lines.

In a crossing like this, too, when the cars are moving in the same direction so that their paths converge, the actions of each should be governed by the speed and position of the other. As shown in Fig. 26, the case of *A* and *B* converging toward the right side of the single street is complicated by the appearance of *C* crossing the path of *B*. In a case of this sort, unless *B* were moving unusually fast and had considerable of a start over both *A* and *C*, it would be the best plan for *B* to slow down, let *C* cross in front of him, *A* meanwhile proceeding down the street. This arrangement would give *A* his crossing in safety and leave him a clear street at all times, while doing the same for both *C* and *B*, the latter under any other plan running the gauntlet of trouble from both of the other sources.

And so it goes, road conditions and situations might be multiplied indefinitely. The best plan is to bear in mind at all times the motto which has been adopted by many societies and associations: "Safety First." This will cover not alone the various crossings and maneuvering on the road, but also the more vital matter of speed. In this latter the only way is to keep within the legal rate at all times, and to drive in such a way as not to endanger other users of the highways at any time.

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**COASTING PRECAUTIONS.**

A word of caution relative to coasting. Many drivers like to go downhill with everything cut out, the car descending of its own weight. This is accomplished by shutting off the throttle when well started on the down grade, and then holding the clutch out. While freeing the car of its biggest drawback—or, more properly, holdback—the engine, this has the disadvantage of taking away at the same time the biggest, best and most certain brake, this self-same engine. While the car does coast more freely, so much more so as to give a feeling of flying almost, the very fact of being on a considerable down grade makes the best brake of the utmost importance. This alone should stamp the practice as dangerous and one which should not be followed or commended.

In passing by horses or through herds of cattle or other animals, the driver should remember that to these animals the motor is a thing of terror, that it frightens them almost without exception, and the least that a good driver can do is to slow down so as to frighten them as little as possible. When passing horses which are pulling wagons with either women or children, if the animals show a tendency to bolt, the driver should stop his machine and help to walk the horses past it, soothing them as much as possible meanwhile.

The best method of holding the steering wheel is open to discussion. Some drivers prefer one method, others another, each with a good argument in his favor. In grasping the wheel at the two opposite sides, as far apart as possible and on a horizontal line parallel to the driver's chest, and with the fingers around the upper side of it, a position is assumed with which no one can find any fault. It has the prime advantage of giving the driver as much leverage over the steering system as is possible, at the same time giving a double grip so that in case one hand should slip there is nothing lost. At the same time, the spark and throttle finger levers may be manipulated by simply shifting one hand for an inch or so.

In case a wide turn in made, the turning may be done with one hand, sliding the other around meanwhile so that in case this is followed by a similar turn in the opposite, the last-named hand can grip the wheel and pull it in the opposite direction quite readily. In case a full turn is to be made, the wheel can be pulled around with the left, say, the right meanwhile simply taking hold as the left pulls it around, and thus preventing a movement in the other direction, much the same as pulling in a rope, when one hand is used for the pulling while the other simply holds it as pulled in.

It has been urged against this method that it tires the arms, this being very noticeable on a long ride. Moreover, with the very low form of seat, it means reaching upward all of the time. For the racy type of runabout, many drivers adopt the method of holding the wheel with a single hand, grasping the rim firmly at the bottom only, either with the knuckles turned up or down, as preferred. By bottom is meant the edge or side which is nearest the driver, and, considering that the wheel is set in an inclined plane, actually is the lowest or bottom point.

For ordinary running along a straight road or pavement, this method is all right, but when any emergency arises, and with a fast-moving car they arise quickly, the driver has a very poor method of controlling the movement of the automobile. Even though it be restful and convenient, this objection alone is a strong one against it.

An intermediate grip might be said to have practically all of the advantages of both without any of the disadvantages of either. This is one in which the hands are separated by one-quarter of the distance around the wheel and at equal distances from the body on either side—that is, the right is one-eighth of the circumference up from the bottom on that side, and the left at an equal distance on the other side. This does not tire as the wide grip does, yet gives a firmer hold than the single-handed method. Moreover, on a straightaway road, with the engine running smoothly and no other vehicles in sight, one hand may be dropped, leaving the other in its usual position. This rests the hand which is dropped but still leaves the driver in a position to control every movement of the car quickly, easily, and accurately.

Knowing the eight items in the control of the car thoroughly and in detail, knowing what things will prevent the motor from running or from acting properly if omitted and forgotten, and knowing and bearing in mind at all times the eight secondary items of the control system, the novice is in a fair way to learn to drive and drive right. If these rules, as laid down on the preceding pages, have been learned thoroughly in conjunction with the actual manipulation of the car, so much the better, for they will have been imprinted upon the driver's memory in a way which will make it impossible for him to forget them.

Learning with book and car side by side is the finest way possible, for the one teaches the how of each lever and rod, while the vehicle gives the actual example and a means of proving the statements made in the book. It serves as well to emphasize these. In a short time, it will be found that many of the movements and actions previously laid down as separate and distinct will have become second nature, so that the driver does not know or realize that he does each one of them every time. Thus, with the clutch, when learning to drive, the operator has to stop and think every time he shifts gears or wishes to check the movement of the car that he must depress the clutch pedal. After a very little driving, this action becomes involuntary, until very soon he is doing it without realizing that it should be, was being, or had been done. The writer has known drivers who have become so accustomed to making these various motions that they did not know they made them, and, in certain cases, denied having done so.

In watching the work of a driver who has reached this stage, it will not be considered that driving is difficult, for the various actions blend off into one another so well and each seems to follow the one before so naturally and easily that only he who is learning realizes that the driver is doing a dozen different things at once and doing all of them well. This is the perfection which all drivers seek and which comes to all only with long practice and considerable experience. It is possible for everyone, requiring only time and patience.

# CHAPTER III.

## Repairs and Upkeep.

AFTER the beginner has mastered the more simple matter of operation of the car—that is, the art of driving—and with it the more simple troubles, their symptoms and remedies, he begins to feel equal to tackling bigger things. Operating the car under all conditions of wind, weather and temperature, to say nothing of all different mechanical conditions, he is prepared to tackle as large a job as comes within the scope of the amateur. This will preclude such pieces of work as *scraping main bearings, retiming an engine, lengthening frames or wheelbases,* and similar work which obviously is for the expert repairman only.

Short of these and kindred matters, however, there is little that the skilled driver of even one season's experience cannot tackle. Over and above keeping the car in condition to run daily and continuously, the first big job in this line which will come to the new driver, barring, of course, any accidents or untoward happenings which will bring along a big and difficult job more quickly, is the fall or spring *overhaul.* By this, reference is had to the first end-of-the-season overhaul of the entire vehicle, taking off the body and taking the mechanism down as far as its condition warrants.

As to the latter, the new driver will require all of his year's experience to tell him where to stop short—that is, where to draw the line between needful work and that which is entirely unnecessary. In the modern car, which has had but one year's careful and considerate use, this may be drawn very early, for cars are so well built nowadays as to require little more than intelligent and consistent care and operation for several years, up to, say, 10,000 miles travel. Beyond that, however, many little signs point the way to small things which need attention, so that the driver begins to say to himself: "I'll take up those bearings when I overhaul the car," or "I'll take out the slack in those rods, or reline the brakes or clutch or lower the seat so as to make it more comfortable or bend the operating levers to clear the body more, etc."

In taking up this work, the first thing to do is to get a good, clear, clean, light place in which to do the work. Of course, it may be done anywhere and in any manner; but by far the best results are obtained when there is plenty of room, lots of light, and considerable thought given to the best of ways and means.

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### How to Remedy the Most Common Automobile Troubles

**98. When the body squeaks, what causes it?** This is a common trouble caused by looseness somewhere. With a wood body it means that some flat piece or panel is not nailed, screwed, or glued as tightly to the supporting timber or post as it should be. Consequently, when the body is racked or twisted by the road surfaces, one surface presses against or rubs over the other.

**99. What is the remedy for this?** If the offending parts can be discovered, screws put through the panel into the nearest post will reduce it materially if not stop it entirely.

**100. What causes similar squeaks in metal bodies?** When the metal is joined to the wood parts, as the dash, the posts for the seat frames or the longitudinals which support the whole body, there is not sufficient fastening whether the means be nails or screws.

**101. What is the remedy for this?** The same as with the wood body: Find the squeaking place, and then nail or screw it down.

**102. Are there other sources of body squeaks and noises, except those mentioned?** Yes; many times the windshield is not properly attached to the body and a noise emanates from this fastening. In general, old cars did not have the fenders attached firmly enough, and as soon as the car had been run a little

Given a proper place in which to work, the first thing is to place the *chassis* in a more or less permanent position, *jack it up* there, and then remove the body. In some cases, the latter is separate from the *dashboard*, when it is a comparatively simple matter of taking out six or eight bolts and then getting help enough to lift it off and carry it to the storage space. In doing this, it is considered advisable to lift one end and place a large wooden cross member under it there, then to lift the other and put a piece of board or scantling under it there, carrying it by means of these.

By doing this, the *varnished surface* is not fingered or scratched, nor is the woodwork in any danger of being marred. It takes several men to lift a body, and this gives a good way of handling it. If the body is not to be *repainted*, it is well to wash it thoroughly before removing, then polish it after moving and before covering. This will leave it in good condition for immediate use, after the mechanical work is finished.

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**WHEN THE BODY IS CONNECTED** to the dashboard, or when the construction of the car makes it necessary to take off the latter, then there is considerable work to be done. This means taking off the *steering post* usually, as well as disconnecting many of the *ignition wires*, also the *lubrication telltale*, or possibly the *lubricator* itself, the *lighting control wires*, *switches* or *pipes*, the *horn connections*, while the removal of the steering gear means disconnecting spark and throttle control.

All of this is slow, careful work, and, since the driver, even if clever at handling the car on the road, is more or less new to all these parts, it is advisable to mark everything. The ignition wires, for instance, should be tied up with a small tag, containing the number of each. Similarly, each part which is removed should be marked, tagged, or otherwise have its position, function, or connection marked so that it will be a simple matter to put it back where it belongs without a great deal of fussing or needless trouble.

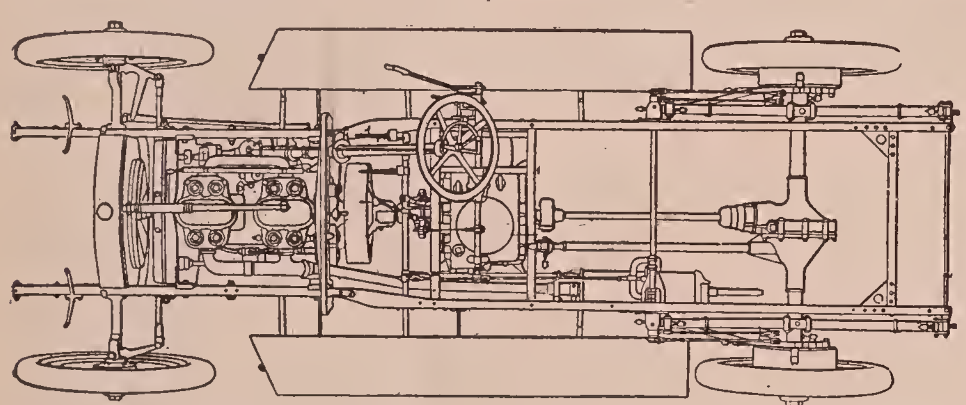

Fig. 27—General appearance of the complete car mechanism when the body is removed.

Having done all this, the driver should tackle as next in order the removal of *rims* and *tires*, or, if these are in the best of condition, of the wheels complete with tires. Taking these off invariably means the disconnecting and removal of the *brake* parts, since all brakes are located in the rear *hubs* now. This is not difficult, since it means but the removal of a few *cotter pins* and then the connecting bolts, after which the rods may be taken off. Removing the wheels is more or less simple, depending upon the type of the axle and its condition. The latter has an influence through rust, wear, or misuse, while the former is a matter of design. Thus of the usual *semi-floating* form it means taking off the hub cap, then removing the *axle nut*, when the wheel can be lifted off bodily, if the brakes have been disconnected.

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ways these loosened up and made a great deal of noise.

**103. Can noisy fenders of this type be quieted?** Yes, by fastening them together or to the frame of the car with a very stout iron, which has plenty of attaching surface where it joins the fender. Use plenty of good big bolts or rivets. If bolts are used, cut off the ends and rivet them over so they cannot come loose or shake off and be lost.

**104. How should any work on fenders be done?** Whenever the amateur finds it necessary to do any work upon fenders or other similar light sheet metal work on his car, he should use a wooden mallet, not the ordinary metal hammer. In addition, he should never hammer or pound on an unsupported surface, but should hold a heavy piece of metal underneath, on the side toward the supporting member.

**105. If this heavy piece of metal be not used, what will happen?** The first blow and all successive ones will simply make dents in the metal work which will be difficult to take out. Moreover, such hammering on an unsupported surface, like the projecting shelf of a fender, only weakens it at its nearest support or puts a permanent bend in it.

**106. An ordinary body is rather heavy; how can one man handle it?** One man cannot handle it; he must have at least one assistant for a small body and three for a large.

Similarly, with the *three-quarter* and *full-floating* types, it is necessary only to take off the hub cap and then the nut on the end of the axle, except in some forms of full-floating in which the *axleshaft* is made without a nut on the end. In the latter forms, removing the wheel means removing the shaft also, which is that much additional work toward taking down the car.

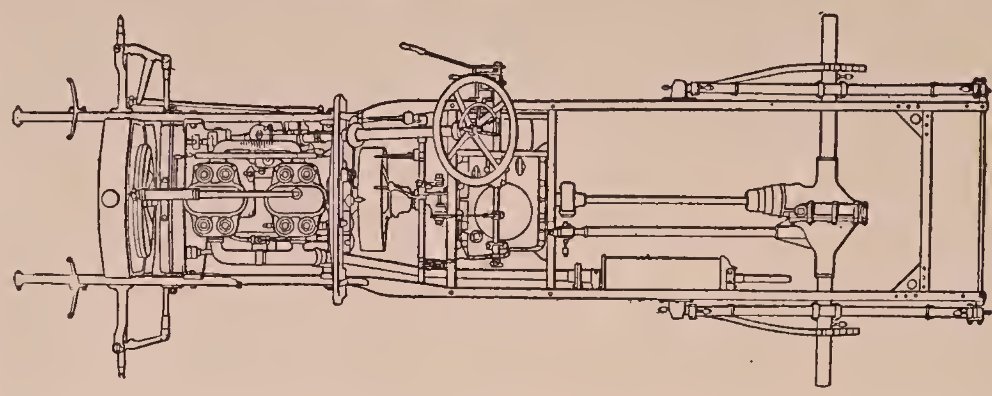
Fig. 28—How the mechanism appears when the wheels, fenders and running board have been taken off.

Having wheels and tires off, the car looks much like Fig. 28; Fig. 27, which was previously shown, depicting the machine before anything was removed. Next in order, the various groups should be removed, as, for instance, the *water group,* consisting of *radiator* and its supports and connections, followed by the *exhaust group,* including *exhaust pipe, muffler, cutout pedal,* with all connections and supports.

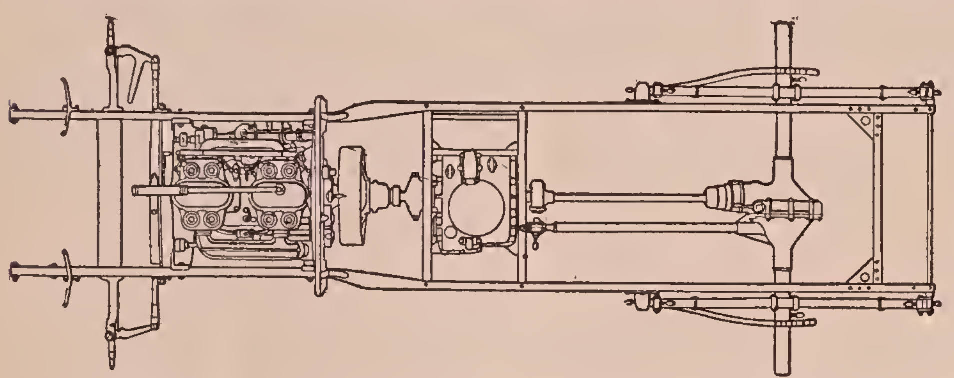
Fig. 29—The chassis from above as it appears when the controlling levers, exhaust system and radiator have been taken off.

Next, the operating levers and pedals should be treated as a separate group and removed all together. This means breaking all connections, taking off not only the levers themselves, but all of their rods and secondary levers, as well as all supports. In this condition, the chassis looks like Fig. 29. Prior to taking off the rear axle as the next step, it is necessary to remove the *torque rod* and the *driving shaft* which connects the shaft from the transmission with the rear axle. In doing this, it may be of service to take off also all *radius* or *distance rods,* or it may not, according to the design.

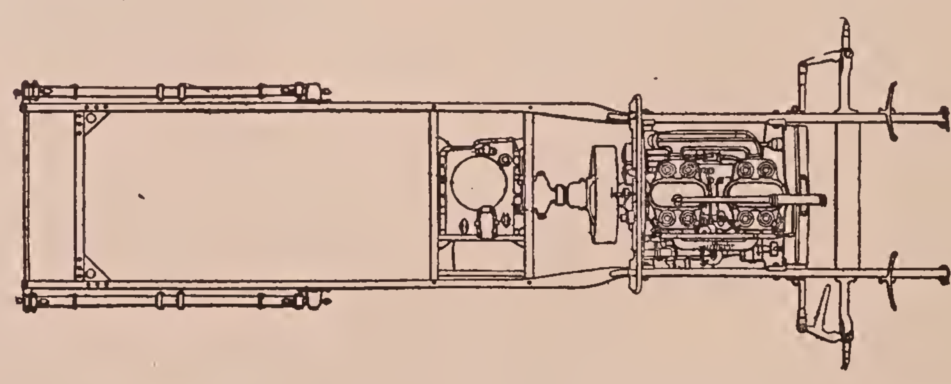
Fig. 30—By taking off the driving shaft, torque rod and rear axle, the chassis is made to look like this.

Finishing up the rear construction, the axle is now removed quite easily by loosening the nuts which hold it to the *springs,* and dropping it to the floor of the garage. Now there is only the clutch, between engine and transmission, to be taken out before either of the big units can be disposed of. This is not a difficult step, for in the usual case there is a *universal joint* on one side, preferably the transmission side. When this is opened, the larger part of the clutch will come out very readily, as one would expect, the joint having been put there for that purpose. In this condition, the chassis has been made to look like Fig. 30.

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On a limousine or other unusually heavy form, at least six men will be needed.

**107. What care should be exercised in taking off a body?** Usually a car body is held on by six or eight bolts. These should be taken off first. Then one end—say the rear—should be lifted up from below and a long cross stick placed under this and above the frame. This should be set central, so that there is room for one or two men to take hold outside of the body on either end. Then the same process should be repeated in the front. Then a pair of horses, a bench or other spot should be prepared for the body when it is lifted off. This done, it is a simple matter to lift it up bodily and carry it to the place designated.

**108. Suppose the car has inside levers, as on almost all 1913 and 1914 forms?** Then, when the front end is lifted, it must be raised enough to clear these when walking backward with the body. This introduces considerable trouble, and may mean that the front end of the body will have to be hoisted up with a crane or block and fall while one set of men lift the rear end and another wheels the chassis forward out of the way.

**109. With reference to the surface of the car body itself.** This should never be touched with the inside of the fingers, as the per-

**TO TAKE OUT THE TRANSMISSION**

depends upon its design; if supported from below, it means holding it up by a *pair* of *jacks,* or other support, while the bolts are loosened, then dropping it down to the floor. If, on the other hand, it is supported from above, the nuts and bolts may be removed, then the unit lifted out by means of a small *crane,* by *block and tackle,* or lifted bodily by two men. It is advisable in tackling as extensive a job as this to make *special stands* for axles, transmission, and engine. With these ready (their construction will be enlarged upon later), the units should be put upon them as soon as removed from the chassis frame. With the gearbox gone, there remains but the frame, springs, front axle, and power plant, as shown in Fig. 31.

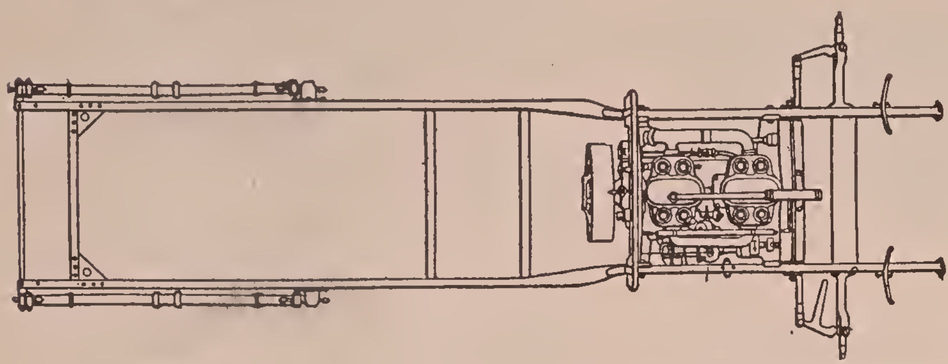

Fig. 31—Next the clutch is removed and then the transmission, leaving the appearance like this.

The last named is next in order. If, as stated before, the dashboard was not taken out at first when removing the steering gear, it must come out now, for its presence will interfere with the more important and difficult job of taking out the engine. In the motor shown, and in many others, the engine *feet* are constructed with a vertical *flange* and a *lip* which rests upon the top of the *main frame.* The vertical portion is drilled for the bolts, which serve only to hold the arms or feet against the side frame member, the lip doing the actual supporting. To take the motor out, one must take off these bolts, and then lift it bodily upward until the lowest portion of the arms clears the frame. It may be swung to either side then and out of the way. The car now looks like Fig. 32—that is, it has been reduced to its lowest terms, nothing being left but the *frame, front axle* and *springs,* and the *rear springs.* There is little reason or necessity for carrying the dissembling process any further, at least in this respect.

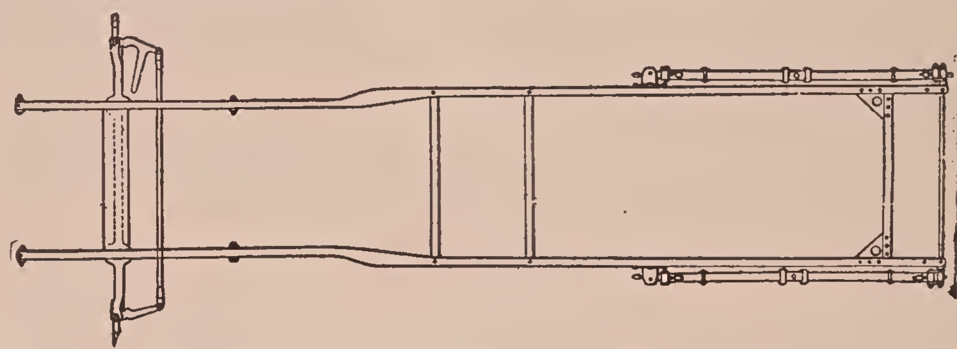

Fig. 32—By taking out the motor and dashboard, the chassis is stripped right down to the frame, springs and front axle.

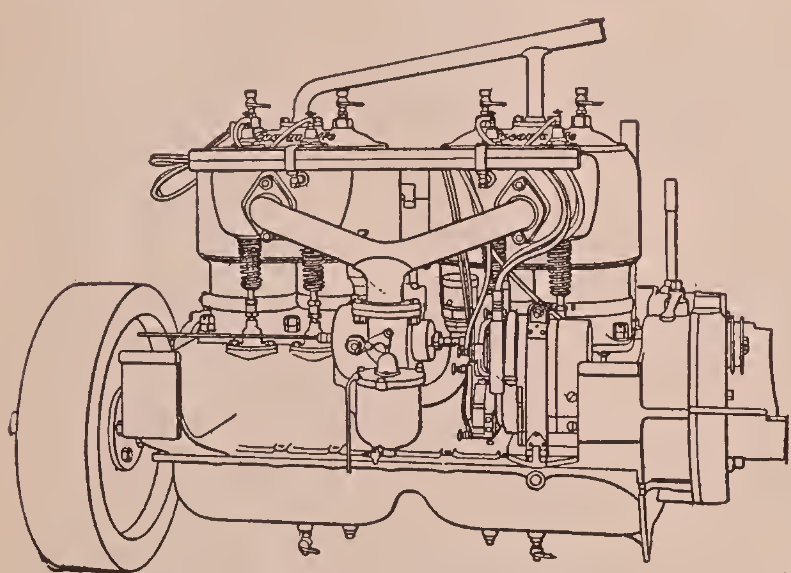

Fig. 33—Appearance of the carburetor or inlet side of the motor, when complete outside of the frame.

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spiration and natural oil exuding there will mark a varnished surface in a manner that can never be taken off except by repainting. If necessary to feel it or touch it, use the backs of the fingers, hand or wrist, where there is no oil to mark the delicate surface.

**110. In case the gas tank is located beneath the seat.** It will be necessary to disconnect this before moving the body, and before that can be done the tank will have to be drained. If any pipes hang down from the underside of the tank into the chassis, these should be disconnected, if possible, and, if not, bent up out of the way. This will be done easily, as all fuel pipes are of copper and easily bent. Care should be used, however, to coil them instead of actually bending, as the latter will put permanent bends in the walls of the tubing.

**111. How should tires be prepared for the winter when the car is not in use?** Take them off the car and wrap in paper or cloth so as to cover them entirely. Then put in a cool, damp place. Heat, air and light are the three worst enemies of rubber, against which they should be protected.

**112. What is a good way in which to do this?** Get from a tire man a couple of rolls of the tire wrapping paper which comes around the tires. By using this, a neat job may be made of it, while the work will be reduced to a minimum. Many owners arrive at the same result by pasting long strips of newspaper together and winding these around the tires. Others do not go to this trouble, but simply put the tires in tire cases or covers and let them lay. This is a good way to do, if there is a case or cover for each one, but they should be hung up if possible.

If any further taking down is required, it will be in the individual units, as, for instance, the engine may have had a very bad *knock* which could not be remedied or even found, as is sometimes the case. It would then be advisable, in giving the car a complete overhaul, to take down the motor far enough to find out where this knock was and what caused it. To go into this matter, in detail, the engine as it is removed from the chassis will look like Figs. 33 and 34, the former showing the *carburetor* side and the latter the *exhaust* side.

On the exhaust side, the first thing to do is to take off the *water pipes* on top of the cylinder, and also those at the lower part of the cylinder *water jackets*. Removing these is simply a matter of taking off a couple of nuts at each joint. Care should be used, however, to keep whole the *gaskets* at the various joints, as recutting new ones for all these joints will be quite a long, tiresome job. The old ones will be satisfactory for this purpose, and may be saved by using a little care.

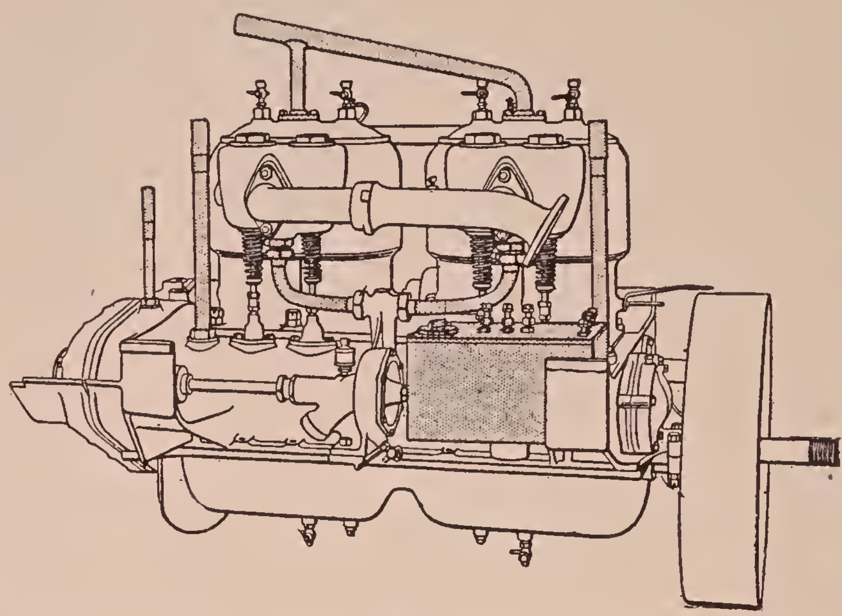

Fig. 34—The exhaust side of the engine before the stripping process has been commenced.

**MAKING GASKETS.** In case the old ones are broken or injured so as to prevent their being used again, new ones may be made from any thick, heavy brown paper, as follows, the figure which illustrates the process showing a driver cutting out a gasket for the *base* of a cylinder. The method, however, is the same, and the tools also. Clamp the member in a *vise* or otherwise so as to hold it firmly. Cut the paper to an approximate size of the outside of the gasket to be made, this being for convenience only. Hold this onto the piece for which a gasket is to be cut, as cylinder base shown in Fig. 35, exhaust pipe, water pipe or other, firmly with one hand, while going over the surface of the paper above the edges of the metal with the flat or *pein* end of a hammer. This will mark it the first time around, and also bend the outer portions of the stiff paper over the edges so the whole will stay in place much better.

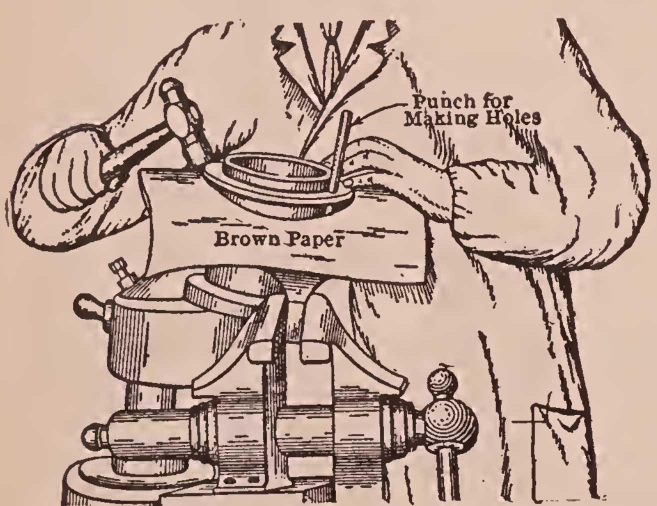


Fig. 35—A method of making gaskets from heavy paper with no other tools than a hammer and a punch.

Next, go around the outer edge again, striking a slightly heavier blow than before, and inclining the hammer face so that it will strike the metal edge at a

**113. What should be done with the tubes?** Take these out and deflate until almost empty. Then hang up in a cool, dry place. If not much space is available, leave them in the casings, just inflated enough to hold the shape of the latter. Then the wrappings of the casing will protect the tubes from the light and air as well.

**114. What can be done to wheels that squeak?** Wheels squeak because they are loosening up, and if the squeak be not stopped will continue until the wheel or wheels are ruined and will have to be replaced by new ones.

**115. How can this loosening of wheels be stopped?** By soaking them in water, which will expand the wood until it is as tight as originally.

**116. Is there any other method?** Yes; by driving in wedges where the joints at the hub have opened up enough to show a crack into which a wedge can be inserted. It is preferable to have these of steel and to have the work done by a wheelwright.

**117. Which is the better method?** The better plan, if the wheels are at all bad, is a combination of both, driving the wedges first, then soaking in water. Then the soaking process will not alone expand the wood, but will wet, and later rust, the metal wedges so that they will cling to their places more tightly, and thus make a better and more permanent job.

**118. If levers are loose where they fit on a shaft, loose enough to cause trouble, what can be done to remedy this, aside by getting new levers?** An excellent plan is to have the worn hole bored out slightly larger and a bushing inserted, the inner hole of which

small angle. The result will be to cut through the paper where the hammer drives the latter against the sharp edge of the metal. Having made a start at any point, follow around the outline of the part with the hammer, striking only as heavily as is necessary to cut through the paper. When the whole circuit has been completed, the outer portion will be cut off and drop down so that attention can be centered on finishing up the inside. In case there are any holes, these may be marked out and cut through, using the *ball* end of the hammer preferably, because of its smaller size. As soon as one hole has been cut, it is well to slip a *punch* or any round piece of iron into this so as to hold the paper from traveling around the circumference ahead of the tool and thus spoiling the gasket.

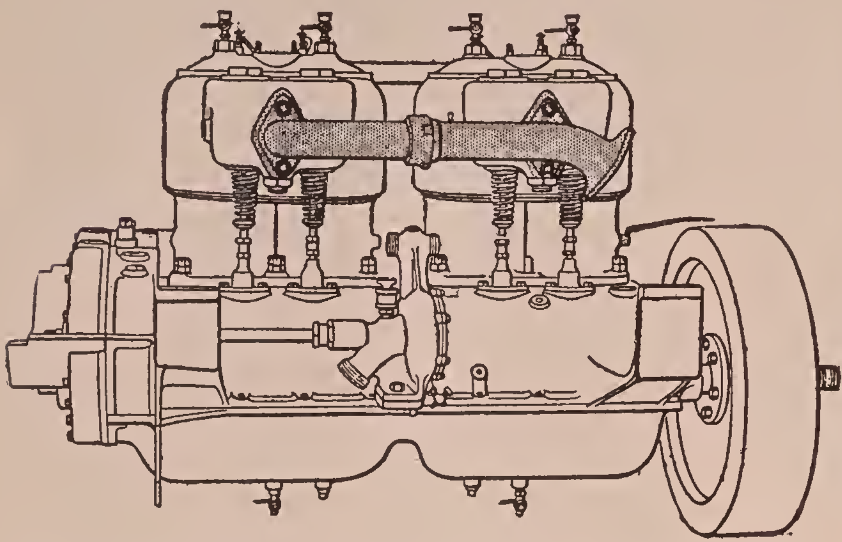

Fig. 36—How the exhaust side of the motor looks ing the piston pins at the left with locking screws. gine crankcase with the oil can removed and the

It may be the case (as with the cylinder gasket shown in Fig. 35) that it will be necessary to cut the inside out first. This is done in the same manner as the outside previously described.

Next in order come the *breather pipes* which vent the crankcase and thus prevent the pistons from compressing the little air which finds its way in there, and thus causing trouble. On the particular motor shown, these are used as crankcase *fillers* in addition, although this is not the case on all engines. Doubtlessly all these pipes will be screwed out, this being the most simple and more usual method of fastening them. If not provided with a hexagon at the base for a wrench, a *Stilson wrench* may be used, or, in case one of these be not handy, a pair of *pliers*, using a pipe to form an extension if they are screwed in very tightly.

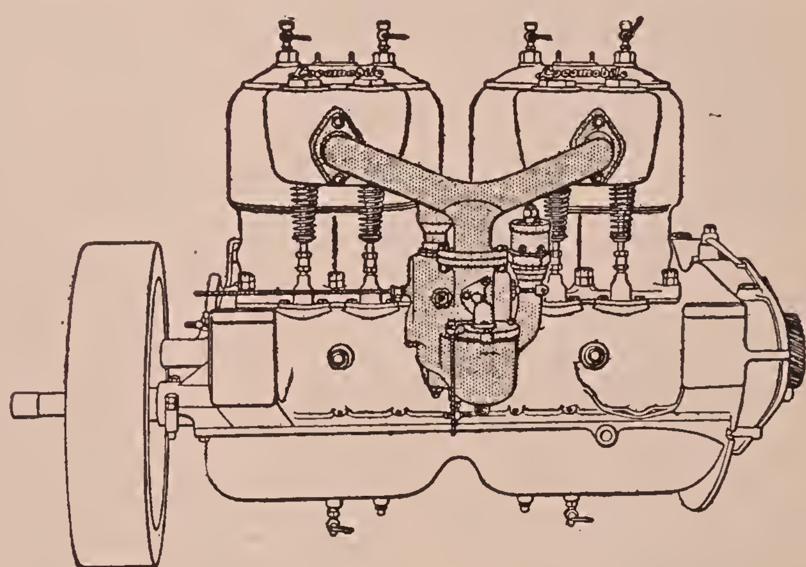

Fig. 37—The inlet side when the wiring, water pipes, standpipes and magneto have been removed.

Next in order comes the lubricator, when such a device is used. This will be bolted in place by means of a couple of exterior bolts, but in addition it will be necessary to break or open the shaft which drives the internal mechanism of the oiler. In a case like that shown, and doubtless in all similar ones, there is a universal joint between the *pump shaft* and the oiler shaft, which may be opened easily. In this particular case, the rear end bearing on the same shaft, shown in Fig. 34, will have to be removed first, but doing so will facilitate taking off the other parts.

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is a very tight fit on the shaft. This bushing can be driven in place. The material of the bushing will vary with the work the lever does.

**119. When the ends of rods wear, how can they be fixed?** In much the same manner by bushing. In some cases, where the rod has an upset or enlarged end—and there is an objection to the bushing method—the metal at the end of the rod may be peened or hammered down into the hole so as partly to fill it up. Then it may be rebored to a tight fit on the pin.

**120. When rod stretches so as to be too long, how can this be remedied?** By having the rod cut and rewelded. This can be done by any blacksmith and is quite inexpensive. By the oxy-acetylene welding process, the length may be made to any exact figure desired. In a case of this sort, the rod should be made as short as can be forced in place, for if it stretched once, it will stretch again, and by making it short to start with the bad effects of this can be minimized.

**121. In general, the stretching of a rod of this kind shows what?** It shows that the cross section of the rod is too small, and if any change for the better is being made, a larger sized rod should be substituted for this. For instance, if the rod which stretched was 7-16 inch diameter, try a ½-inch rod in its place.

**122. If a rod is not adjustable, and its length is not right, how can this be corrected?** The best way is to make it adjustable. This can be done by buying a standard turnbuckle for the size of the rod (its diameter, 7-16, ½,

When all this has been done, that side of the motor begins to look somewhat bare as Fig. 36, which depicts it at this point, shows. On the other side of the motor, a similar line of procedure will be followed, beginning with the *magneto* and ignition system complete. First loosen the connections between *wires* and *spark plugs,* and take out the latter. Then loosen the other end of the same wires at the magneto. If a *bus bar* is fitted, remove this and the wires with it by taking off the few screws which hold it to the side of the cylinders. A simple strap holds the magneto in place so that loosening this will allow of lifting the current generator out, it being necessary first to turn the motor over so that the magneto member of the universal joint in the driving shaft is vertical and thus in a position to permit the lifting process. With the current generator off, there is no further need for the retaining strap, which is removed by taking out a retaining pin on either side of it. In this position, the carburetor side of the engine looks as shown in Fig. 37, that side being more or less stripped with the exception of the vaporizer itself, which is the next to receive attention.

In the motor shown, this is a very simple job, for the *inlet pipe* is a perfectly symmetrical two-branched unit with two bolts in each. As there are no other connections, removing these four nuts or bolts, as the case may be, allows of lifting off the entire device with the inlet pipe. To remove the latter from the vaporizer, take out the two bolts which hold the *flange* at the lower end of this to the upper flanged end of the carburetor *outlet pipe.* With the carburetor off, the engine is as shown in Fig. 38, which will answer as well for the exhaust side, since the cylinders are symmetrical, as soon as mention is made of exhaust pipe and *pump.* The former is held to each cylinder unit by means of a pair of bolts. Loosening the nuts on these allows lifting off the pipe, which may then be separated into its two components if desired.

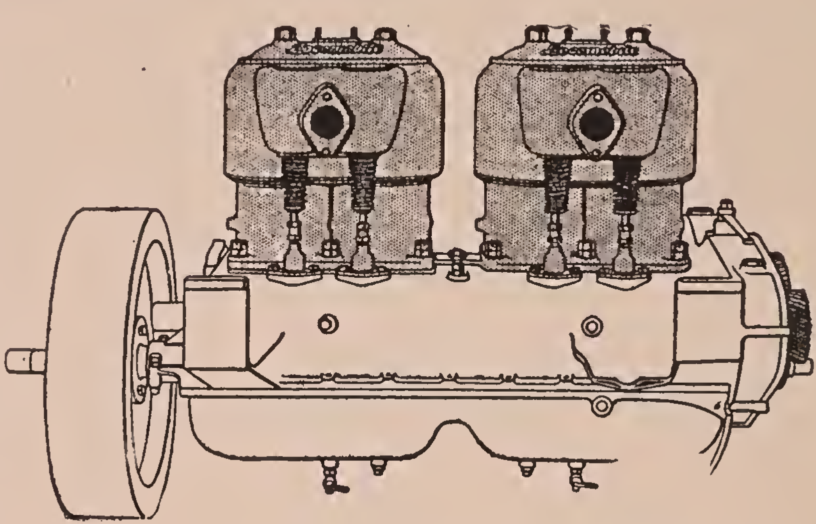

Fig. 38—Another view of the inlet side after the removal of carburetor and inlet pipe, also pet cocks.

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**TO TAKE OFF THE PUMP,** it is necessary to open the case and loosen the nut which holds the *impeller* on the shaft. Then the former may be lifted out. Next the *packing glands* on the shafts should be loosened, after which taking out the single bolt which holds the pump case at the bottom to the crankcase will allow lifting off this member, but will leave the shaft still in place. To take this out, the *gear cover* at the front of the motor is taken off by removing the twelve or more nuts which hold it in place. Then the *pump gear,* with the shaft complete, is lifted out. As it happens, these are *spiral* gears, so that it would be necessary to screw it out by turning and pulling at the same time; but with any other engine on which straight-toothed gears were used it would be pulled straight forward.

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etc.), and then cutting a short piece out of the rod in some convenient place and threading the two ends to fit the turnbuckle. In this, it should be remembered that one must be threaded right hand and the other left, so that turning the turnbuckle tightens up on both. Any one can thread a rod end. Simply hold it in a vise, then apply the die and by means of the die stock or handle turn it around continuously. As it is turned, it screws on, cutting a thread as it progresses. Use a light machine oil on the rod ahead of the die, as this is a case of a hard metal cutting a soft one and a lubricant is needed.

**123. How is a rod of this sort assembled?** The end is put in place in its respective pin, then the turnbuckle is screwed onto it a considerable distance, and the other end screwed into the buckle until it seems about the right length, close enough, at least, to allow of putting it in place on the other pin. Then when both pins have been fastened, the buckle is pulled up with a wrench until the exact length is obtained. For small sizes use a turnbuckle with square sides, for the largest rods, an eight-sided form will be found good, while in the medium sizes a hex or six-sided buckle will answer nicely.

Before removing any of these gears, it is well to *mark* them, as in this way only can the worker be sure of putting the various parts back in their correct places and thus insure the proper running of the motor. To do this marking, all that is needed is a hammer and a *center punch.* Start with the crankshaft gear, and mark a line across a pair of meshing teeth on this and one of the *camshaft* gears, indicating this by means of a *scratch* with a *single* prick punch *mark* on each gear as near the edge as possible. Without moving any of the parts, mark at the same time a similar line on the crankshaft gear and the other camshaft gear, using a scribed *line* and *two* prick punch *marks* on each. Then, again without moving any of the members, mark the exhaust camshaft gear and pump gear with a scribed *line* and *three* prick punch *marks.* The method of marking these is shown very plainly in the figure on this page, Fig. 39.

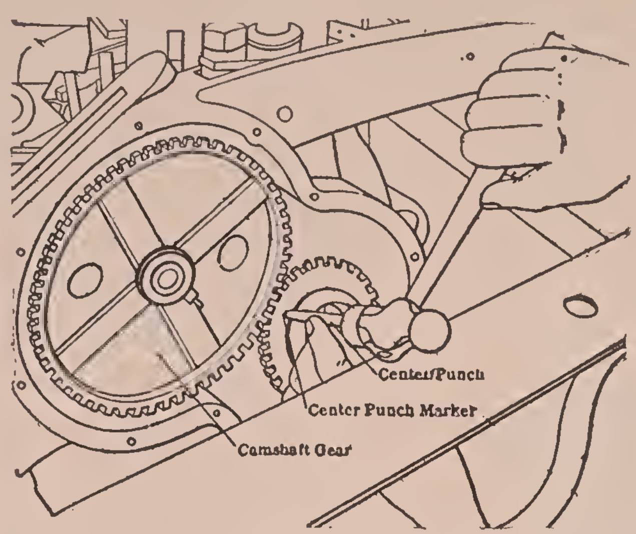

Fig. 39—Method of marking the timing gears with a prick punch so that the relations, one to another, may be preserved.

Take the *pet cocks* out of the cylinder *heads,* and the other gears out of the gear cover, when you will be ready for the next job, taking off the cylinders. This is not an easy job or one to be tackled lightly. Six bolts hold down each *paired* cylinder unit, these in the case of individual cylinders amount to four per cylinder, and with a block motor to perhaps eight in all. Taking off the *nuts* of these, the cylinder unit is lifted straight upward by main force. If a small portable crane is handy, use this as the cylinder is not only heavy but each of its pistons fits tightly enough to make this a two or three-man job, if some kind of apparatus be not available. The *valve mechanisms* will take care of themselves, the valve with its *spring,* etc., remaining in the cylinder, while the *tappet* portion with its operating mechanism stays complete in the crankcase.

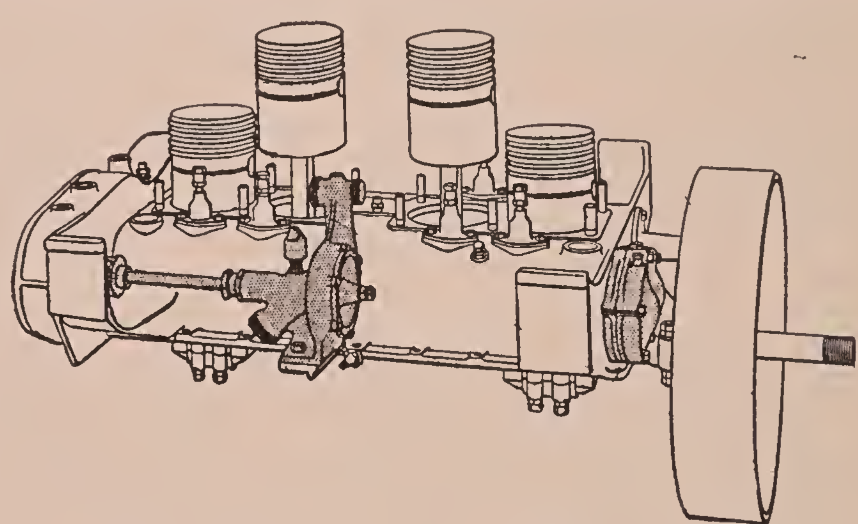
Fig. 40—The motor base, with pistons, after the cylinders have been taken off and before starting work on the internal parts.

After this has been done with both cylinders, and these laid aside, either before the valves are taken out or after, the crankcase will look somewhat like Fig. 40, except that the pump and shaft have been removed, as well as the oiler shaft bearing. One additional unit—the *lower half* of the crankcase—has not been mentioned. Before taking this down, open the pet cock in it, and drain off all *oil,* saving this, as it has uses, even though it be somewhat dirty. Then loosen, from below, the ten or twelve bolts which hold the two *halves* together, and the lower one, which is but a shell or covering, will come right down. If done with

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**124. In taking off a rear axle, what is the first point?** Generally, it is best to loosen the connection between springs and axle, the spring bolts first. If the spring is above the axle, these will be on the underside, but if it is underslung, they may be on the upper side, although generally the lower is preferred.

**125. When this has been done, can the axle be removed?** Not unless the only connection between the front and rear ends of the driving shaft is a slip joint, which will allow of pulling the two apart. In that case, the frame may be lifted up out of the way and the rear axle and driving shaft pulled right out.

**126. Is this construction unusual?** Very. In general, there will be a universal joint in this driving shaft, and it will have to be opened up or loosened before the rear axle can be removed. In cars with a torque rod, this will have to be loosened up at its forward end, while those cars which use radius rods on the two sides in place of the central torsion member will have to have both of those freed from the frame at their forward ends.

**127. How can a transmission be taken out of a chassis?** It depends entirely on the method of supporting it from the main frame or special subframe. If laid on top of this, the removal of the holding bolts and the loosen-

care, this may be dropped down first and emptied of its oil content afterward, but this is an unhandy thing to do, for it must be brought down in a vertical line for fear of losing some of the lubricant.

**THE REMOVAL OF THE PISTONS** is the next job. This is accomplished by reaching up inside of them and loosening the *studs* in the *wrist pins* which hold the latter in place. Holding these in place in the pistons is the same thing as holding the pistons in place on the wrist pins, for neither one can move sideways without loosening the studs or set screws, although both may rotate in a vertical plane through the piston and connecting rod center. Having loosened a pair of these studs—usually there are two to a piston—the piston pin is driven out of the piston, after which the latter may be lifted off. This operation then gives the removal of piston pin and piston also at one stroke.

In the outline drawing, Fig. 41, the piston, connecting rod, and piston pin are complete at the right-hand cylinder, everything being in place. From the second piston the rings have been removed. From the third the studs have been taken out, piston pin removed, piston taken off, and then pin and studs put back in place to show how they go together. On the fourth cylinder the set screws have been taken out, the piston pin has been driven out, the piston has been taken off, and the pin set back into place partly.

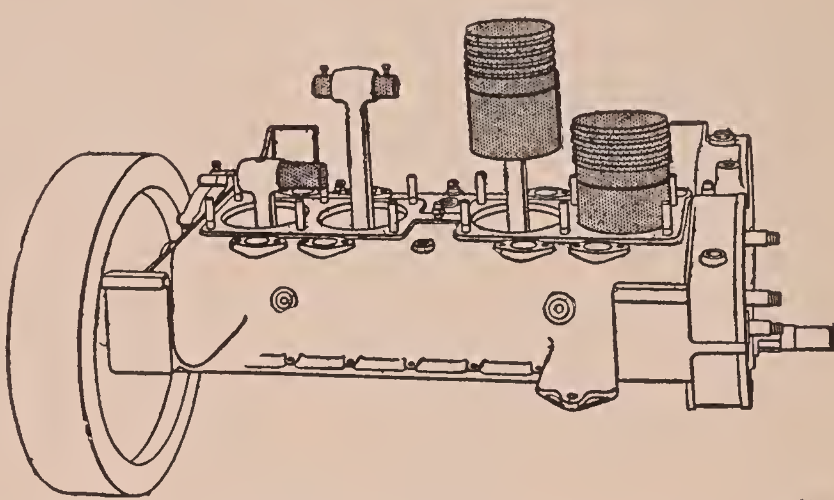

Fig. 41—Beginning to take off the pistons, showing the piston pins at the left without locking screws.

This sketch shows clearly the method of procedure and the manner in which the work is advanced. In the matter of removing piston *rings,* however, there is considerable difference of opinion. It is conceded generally that this work may be done more easily with the piston held firmly in a vise than when loose or free to turn as in this case. When the job is done in that manner, the workman can give all his attention to the puzzling task of getting the rings out of their *grooves* and off the piston without breaking any of them, this being a very ticklish matter on account of their being made of *cast iron,* which is very *brittle.*

The way in which this should be tackled is as follows: Get some thin, flat strips as narrow and thin as possible, old hacksaw blades which have been applied to the emery wheel to take off the teeth being excellent, or old corset steels broken into short lengths. Any thin and narrow strip will do. About four to a piston are needed, although if but three are available, the job can be completed with this number. Clamp the piston in the vise at its lower end, just below the last ring, being careful to use *copper* or other soft metal strips so as to get a tight grip on it without cutting or marking its surface.

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ing of its connection with the clutch, by universal or slip joint, as well as with the shifting rod, supposed to have been taken off previously, will allow of lifting it upward and out.

**128. What is the difference if it is hung from below?** None, except that it is not so easy to work upon, for as nuts are loosened up the weight of the transmission drops it down upon the worker. This necessitates its connections with clutch and shifting means being disconnected before touching the holding bolts. In loosening the latter, it is best to have a jack or other method of variable support underneath the transmission, so that the bolts may be removed entirely without the operator being obliged to bother with the weight and bulk of the transmission case. Then, with everything disconnected or loosened, the jack may be used to lower this to a point where it can be lifted out from under the chassis.

**129. Does this same method apply to the engine?** Yes, except that no one tries to lift an engine out because of its greater weight; a crane or block and tackle is used for this purpose. The removal of the transmission generally loosens the rear end with the exception of the clutch shifter connection. The removal of the radiator makes it possible to lift the front end straight up, then there remains only the question as to whether the flywheel projects under the dash or not. If not, the holding bolts may be removed and

Having done this, insert some tool or pointed instrument under one end of the lowest ring and pry it out of the groove so that there is a clear space between its inside edge and the piston outer walls. Into this slip one of the strips mentioned previously. Then without using the pointed tool, work the strip around to the back of the ring, finally leaving it so that its upper end extends above the top of the piston, while the lower end is well over and below the bottom groove in the piston, about as shown in Fig. 42.

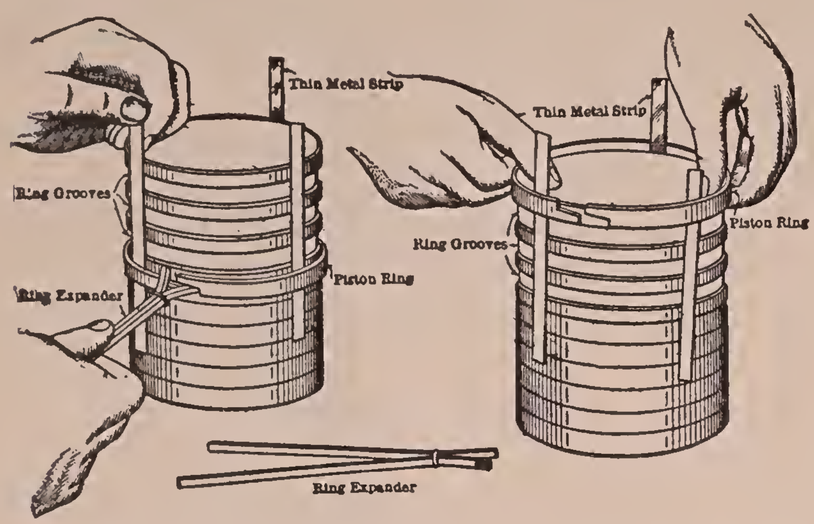


Fig. 42—How piston rings are taken off with a minimum of trouble and no appreciable breakage of these brittle parts.

Then insert the tool again and slip in another strip, which work around to one side—say, the left. Repeat this operation with a third strip, which work around to the right. Then with three strips in place, equally distributed around the circumference of the piston, you are ready to take off the rings. That is, you are ready, unless you prefer to put in a fourth strip in order to make the removal more easy. Either number will hold the ring out beyond the surface of the piston, so that it may be drawn upward slowly but surely to the top of the piston, where it is removed. When this is done, the strips of metal will fall off onto the workbench. They may be used to repeat the operation with the other rings.

**TAKE OFF BOTTOM RINGS FIRST.**

In practice, it has been found easier to take the rings off commencing at the bottom and working upward than the reverse. Moreover, in replacing them, it has been found easier and quicker to work from the top down, putting back the top ring first and the bottom one last. In replacing piston rings, those taken off from any one piston always should be replaced on that piston, but it is not necessary to put them back in the same groove as before—in fact, it is a wise plan to put the ring taken off at the top back on at the bottom, that from next to the top back on next to the bottom, and so on, thus inverting the previous order.

There is a good reason for this: The top ring does the most of the work in holding *compression,* while at the same time it is more exposed to the *heated gases* than any of the others. For these reasons, it is sometimes burned off, while *carbon* collects behind it, as well as above and below it, in the *slot* when wear has occurred there. Since the lowest ring acts more as an *oil ring* than for holding the compression pressure, that one usually keeps its stiffness for the longest time. This is why it is advisable to transfer the top ring, which is liable to be weak or somewhat worn, to the lowest groove, where it has less work to do, and the bottom ring, which has remained the stiffest of the group, to the top where this strength may be more useful.

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the engine hoisted out. If not, the dash must be taken off first, which is a considerable job.

**130. What is the best method of removing piston rings?** By hand, using flat strips of steel around the piston. This method is slow but sure, and it does not break the rings unless the worker gets careless or impatient.

**131. If the rings are loose in their grooves, what should be done?** If they are loose vertically, new rings must be obtained to replace them.

**132. What is to be done if they are loose horizontally?** They are made that way, but it is possible that much carbon has collected in the grooves behind the rings. If so, this should be scraped out clean and polished up bright with denatured alcohol to make sure that all carbon is removed.

**133. What should be done with weak rings?** If very weak, throw them away and buy new. If the top ones are found weak while the bottom ones are still stiff and strong, take them all off, clean the grooves, then put them back with the stiff ones at the top where they are needed most and the weaker ones at the bottom.

**134. Suppose the rings are badly worn?** If the wear is so great that they will not fit the cylinder tightly under any circumsances, they must be discarded in favor of new ones. Some clever repairmen are able to take a

Reference has been made previously to prying out the piston rings from the grooves by means of a screwdriver or any pointed tool. This is not necessary if a special tool be employed. There are a number of these on the market, or a simple one may be constructed as indicated in the cut (Fig. 42). This consists of two small and narrow pieces of very stiff steel and of equal lengths. They are bent near one end, both being bent the same amount. In assembling these with a tight clip of metal, the pieces are set togethr in such a way that the bent portions are away from each other. To make the short ends approach one another, it is necessary to spread the long ends far apart. This would be the condition under which the short ends would be inserted between the piston ring ends for the purpose of spreading them. When the long ends are again pressed together, the short ends will be spread apart which is the desired effect. A tool is made along similar lines for handling rings with diagonally cut ends instead of the stepped form for which this tool is applicable and which is shown in the figure.

To return to the dissembling process, with the four pistons out and laid aside on the bench for the later removal of piston rings and general cleaning and inspection, as well as the four piston pins, the balance of the gears should be removed from the gear case at the front end of the crankcase, as previously spoken of. Usually these present little difficulty, being set on the ends of the camshafts by means of a tapper and nut, nut and *key,* or tapper key and nut. When made integral with the shaft, they should not be taken out at this stage of the proceedings. The removal of the camshafts will be described later.

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**THE CONNECTING RODS** represent the next point of attack. In general, these are of two kinds: Those with *two* bolts, and those with *four.* There was formerly a third type, which is no longer used, namely, the hinged form, in which the cap was hinged to the rod proper at one side so that a single bolt at the other side sufficed to hold cap and rod together. The bolts on the connecting rod big end may be of the *through* bolt type with a head, or they may be *studs,* which have been screwed into the rod wet so as to rust in place, or they may have been pinned in place by means of very small pins driven through them and the rod.

In either case, the driver will find them firmly fixed so that they will not turn. The nuts now in use are of the *castellated* type—that is, the upper portion is cut across in three places. This makes a place for a cotter pin to lie down close into the nut and thus prevent it from turning. The stud (or bolt) is drilled at its outer end where the nut is used, this hole being for the cotter pin. To remove the nut, take out the cotter pin, then screw the nut off in the usual manner. When this has been done to all the nuts, the cap may be lifted off. It then will be possible to lift the connecting rod off the crankshaft. By following similar methods, all four (or six, as the case may be) connecting rods may be taken off.

If these are not marked, the driver should be sure to mark them as he takes them off, for it is of the highest importance that they be put back in the same place they occupied previously. The crankshaft bearings are the most carefully

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pair of very old worn rings (on a discontinued motor) and by placing one inside the other—that is, two worn rings in a groove—are able to reduce the number of new ones which must be made especially to one-half and still get good results. Such an arrangement would not give a perfect ring, but by putting the thick part of one opposite the thin end of the other a fairly even expansion will be produced, which will cause the outer surface to hug the cylinder walls closely.

**135. What is the test for a properly fitted connecting rod bearing?** When the big end bearing of a connectig rod is properly fitted, the upper end will stand in whatever position it is placed down at an angle of more than 15 degrees with the vertical, when it will swing down past a short ways and then continue swinging, but not too freely, until it comes to rest. In any position up to 15 degrees it will stand firmly. There should be no side play, either.

**136. How do clutch and brake linings differ?** In every possible way; one is a straight material of even width which may be obtained in rolls the same as cloth. The other must be cut to fit the individual job.

**137. Are they applied similarly?** In that both are riveted in place, yes. Otherwise, no. The clutch lining must be stretched into place on a curved surface, a difficult job and a slow one. Brake lining is simply wound around the surface, cut off, one end held and riveted. Any one can do the latter fairly well, the former requires an expert or a combination of great patience with considerable mechanical skill.

fitted on the car, each one being fitted individually to its bearing pin and with the bearings in a certain position. Thus it may be seen that the interchange of two caps or two rods, or even two bearing halves, would upset the proper fit of two bearings which existed previously, and replace these with two which do not fit and which will rub, heat, wear and cause much trouble, besides absorbing a great deal of power. In general, the cylinders are numbered from the radiator back, as 1, 2, 3 and 4 (also 5 and 6 on a six-cylinder motor). It is a good plan to carry out the same scheme of numbering on connecting rods, crankshaft cheeks, and other parts when taking down the whole motor.

**THE FLYWHEEL** comes next, the removal of which is a comparatively simple matter. This is held in place by means of six or sometimes eight bolts. After taking off the nuts of these, the balance weight may be drawn straight off, although its weight and tight fit combined may make this a job for two. On some flywheels, an extra hole is bored beside the bolt holes, this being for a *dowel pin*, being bored in such a position it cannot be put on without bringing all bolts and bolt holes into a correct and proper register. In this way, when the flywheel has been balanced with the shaft there is no possibility of this being lost by incorrect assembling. If the car be an old one, the flywheel may be found to be held on the crankshaft by means of a tapered portion with a key and nut. In this case, it is a simple matter to take off the locknut, then the nut, then start the wheel on the taper, after which it will come away very readily.

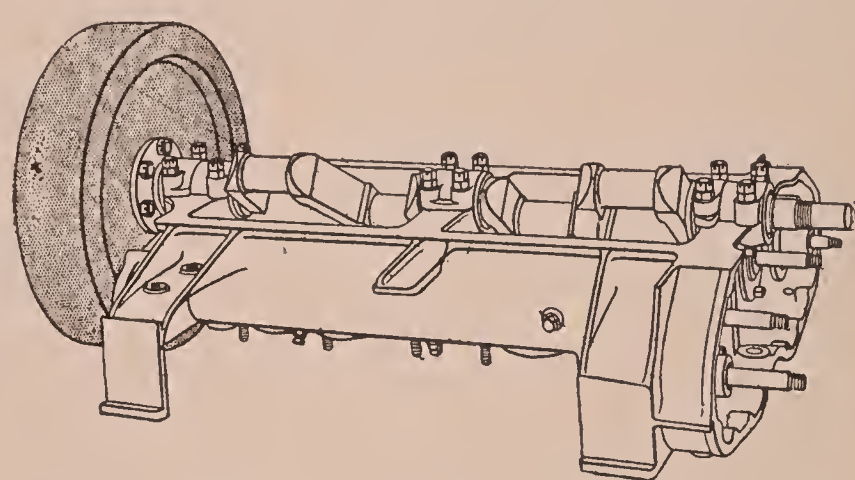

Fig. 43—Appearance of the underside of the engine crankcase with the oil can removed and the gears taken out.

With this member disconnected, there remain but the crankshaft and the two camshafts. The former is an easier job than the latter, but a more important one; for, like the connecting-rod parts, all the main shaft bearings must be marked carefully and their exact positions noted so that they may be replaced in the original manner. The actual removal is nothing more than loosening the nuts of the three or more bearing caps, taking them off, then the caps, and then lifting out the shaft.

Taking out the camshafts, on the other hand, means loosening up the bearings first, then working the shafts out with the cams and bearings. The position of these shafts and their peculiar duty is such that the cams usually are made integral with the shafts. Moreover, this necessitates the shafts being somewhat long and removed from the end of the motor in a lengthwise manner. This, in turn, calls for a style of bearing which can be applied to the shaft before putting it in the engine, which may be removed with it from the front end, and which will find a permanent and positive seat within the motor. Usually the front

**98A. If the flywheel must be removed and it sticks?** Get a wheel puller, or if you do not want to go to this expense, make one by using a rope, chains, cable or something similar and a jack. The base of the jack is put against the projecting end of the shaft, the chain or cable is fastened around the flywheel and over the upper or lifting end of the jack, and as tightly as possible. Then by working the jack out using the regular handle, the flywheel is forced off from its shaft gradually.

**99A. What are flywheel pullers like?** Usually they have a spider-like form with three projecting ends, each one of which has a sort of claw or bent over tip. These are made to catch on the back side of the flywheel, while a hub rests against the center of the outer end of the crankshaft. In the latter there is a screw which can be turned. When the apparatus is in place, the screw is turned and first takes up all of the slack in the arms, making them clutch the flywheel tightly. Then a continued turning, pulls the heavy weight along the shaft and off. In general, flywheel pullers are much the same as wheel pullers, which were made formerly for the old style of axle in which the wheel was very likely to be a tight fit on the axle shaft and had to be forced off of it by main strength.

**100A. In the modern engine is the sticking flywheel usual?** No, very infrequent, first because it is made and fitted better, and

bearing is of the *ball* or the *plain* type, located in the cover of the gear case, so removing the latter takes care of one of the three. If the other two are of the plain or of the ball type, a set screw suffices to hold them on their seats, so that in removing, after the gear cover has been taken off, it is necessary only to loosen these two set screws, when the shaft is in a position to be removed without further work.

Fig. 43 shows the motor, after the connecting rods have been removed, this being with the crankcase inverted so that the bottom side is uppermost, the manner in which a good workman would handle it. Fig. 44 shows the same upside-down view of the parts that are left, when the flywheel has been taken off and only the crankshaft and camshaft remain in the way of ultimate taking down.

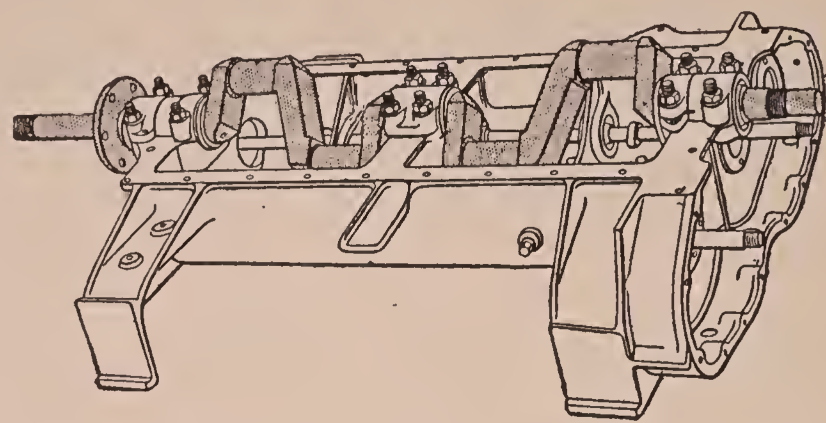

Fig. 44—The motor crankcase after the flywheel is off, but before the main bearings have been disturbed.

**IN REBUILDING THE MOTOR** and car, after inspection, readjustment, renewal, and lubrication of the parts has been completed, the process described above is repeated in the reverse direction. That is, the directions for taking down will serve for building up, if just turned around. While this goes into the matter much further and in greater detail as to the extent of the work, than any new or amateur driver would be likely to do, the parts which he would be likely to use will be just as useful as though given separately, while the giving of the entire job gives him an excellent insight into the various parts, their interrelations one with the other, their functions and methods of construction, which could not be gained in any other manner. Thus, take for instance the matter of removing a cylinder to replace a piston ring; this will be found to have been given previously in sufficient detail to permit completing the work without additional information, although it was given here as but an intermediate step.

Some of the smaller items of car-repair work present a nice little problem each in itself. Thus, in such matters as relining a clutch or a *brake shoe,* there is an opportunity for the exercise of considerable personal skill, not a little headwork and planning, and considerable time and patience, as both these are tasks which the driver is liable to have at any time. Relining a brake is a more simple job than the other, for a brake drum surface is a section of a perfect cylinder, while the lining material comes in a variety of widths. The driver has only to select the right width, measure around the outside for correct length, allow about an inch where the two ends approach each other (an inch short of a full circumference of the cylinder, because in applying the brakes the lining ends are pulled toward one another; if they met, the brake would be prevented from gripping there) and cut off.

second because a means is provided on the flywheel itself for taking it off.

**200A. How is this done?** A pair of extra holes are drilled on the opposite side of the hub and threaded. When all the other bolts have been removed and the flywheel will not pull off, a pair of studs or bolts are inserted into these, and by screwing in on them, the inner ends push against the flange on the shaft, and thus force the unit off.

**201A. Are flywheels as heavy as formerly? No, very much lighter.** The first automobile engines were of the one and two-cylinder types which required a very heavy wheel to give them good balance. As fours came into general use with better natural balance, this weight was reduced, while the six needs even less than a four, having a still better natural balance. Sixes have been made without any flywheel whatever. A further means of reducing flywheel weight was the reduction in reciprocating parts and the better balance of crankshafts, which made the need for a heavy flywheel weight less.

**202A. Has the starter had any influence upon flywheel weights and sizes?** Yes, the presence of a starter always ready and able to turn the engine over for a considerable length of time, has led a number of designers to reduce their flywheel weight. In addition, one type of starter is incorporated in the flywheel and takes the place of a large part of its weight. This is brought about by the rotating field of the starter

The application is almost as easy, for the surface is perfectly plain. One end is put in place and held firmly by means of a *clamp*. Then the material is stretched around as tightly as possible and held by the use of another clamp. The first end is now drilled through the material for a couple of *rivets*, using the holes which are in the brake bands as a guide. For these rivets, copper is used with a head which is placed on the inside. This brings the work of riveting over, which necessitates pounding with a hammer on the facing instead of the metal of the band, which may include, and often does, a more or less brittle casting. In this way, too, the rivet on the exposed side is driven into the facing more or less, which is desirable, for then there is less possibility for a projecting portion cutting the brake surface.

When a pair of rivets, one on either side, have been applied at the end, the material is again pulled as tight as possible, and another rivet applied on one side, the second one on the other side being set ahead of it—that is, the rivets are put in staggered. After each pair of rivets, the clamp is loosened and the material pulled up tight again. In this way, all of the stretch is taken out of the material in the beginning, and the only change in the surface of the brakes which can come through use is the wear, which is inevitable.

**LINING THE CLUTCH** is a decidedly different proposition, although the main difference comes in the planning, cutting, and stretching of the material, and not in the actual riveting. The reason for this lies in the fact that the shape of the usual clutch is a *frustrum* of a cone, consequently the surface is conical—that is, larger in diameter on one side than on the other A typical cone clutch, as shown in Fig. 45, will show this very plainly. Here it will be seen that the inner edge, as marked *C* and *J*, shows a smaller diameter than the outer edge, here marked *D* and *I*.

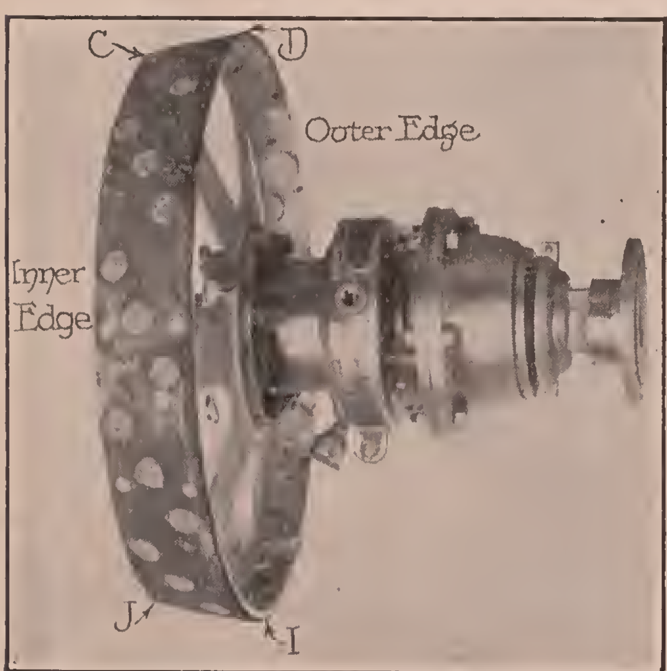

Fig. 45—A typical cone clutch, with cork inserts, showing the dimensions needed for laying out a clutch lining.

If the upper surface, as indicated by a line from *D* to *C*, be prolonged, it will meet a similar line through *I* and *J* upon a prolongation of the center line or axis about which the clutch rests. If the cone could be rotated about this point, either *D* and *C* or *I* and *J* would generate an annular ring of this width which would fit exactly the surface of the cone, since it would produce by so rotating a measure or pattern of its surface.

This gives the clue to the method of laying out a clutch *leather*, this being shown in Fig. 46. Before starting this, the diameter of the two sides of the cone, namely, *C-J* and *D-I*, of Fig. 45, should be known and measured accurately. In addition, the width *C-D* (or its equivalent, *I-J*) must be known. Lay these out

having a considerable mass and weight, and in addition being located at a considerable distance from the shaft center. Thus, it presented all the elements necessary in a heavy flywheel, and as a consequence, the latter could be eliminated or reduced practically to a minimum.

**203A. If a knock is traceable to one end of the cam shaft and noted to occur only when the cams at the end of the shaft begin to lift on the valves?** This is a sign that the bearing at that end of the camshaft has worn sufficiently to allow the camshaft to move each time the cams begin to exert pressure upward, and to move again when this is ended and the shaft drops into its normal place.

**204A. How else might the same noise be produced?** The shaft might have become bent between the two last bearings, either through the use of a poor grade of steel, through too small a size, or through a flaw in the one fitted. In rotating this would cause a knock whenever the high part came up at the same time as the cams came into action.

**205A. In either case, how is this remedied?** By taking out the shaft and replacing the end bearing, or all the bearings if necessary, in the one case, or by straightening the shaft in the other.

**206A. Is it possible to make a shaft which has been bent in such a manner as described above, perfectly straight and true?** No, this

on a piece of paper, as Fig. 46 shows, and prolong the center line *A-B*, about which they are laid down, off to the right for a considerable distance. Then prolong *D-C* to meet this, and similarly *I-J* to meet it. If the work has been done correctly, both the measuring and the laying out, these two lines should meet the centerline at the same point, as *B*.

From this point, with a radius *B-C* (or *B-J*, which is the same thing), lay off the circle *H-J-C-F*, and with a similar radius *B-D* (or *B-I*) draw the outer circle *G-I-D-E*. Now, having measured the largest diameter of the cone, *I-D*, Fig. 45, the circumference there may be figured; or, if preferred, this may be measured directly upon the cone over the old lining. Knowing this amount, lay it down upon the larger circle, as from *E* to *G*, and draw radial lines from *B* through these two points, as *B-F-E* and *B-H-G*. This outline, *E-G-H-F-E*, represents the pattern upon which the clutch leather must be cut in order to fit the cone shown when it has been stretched upon the same.

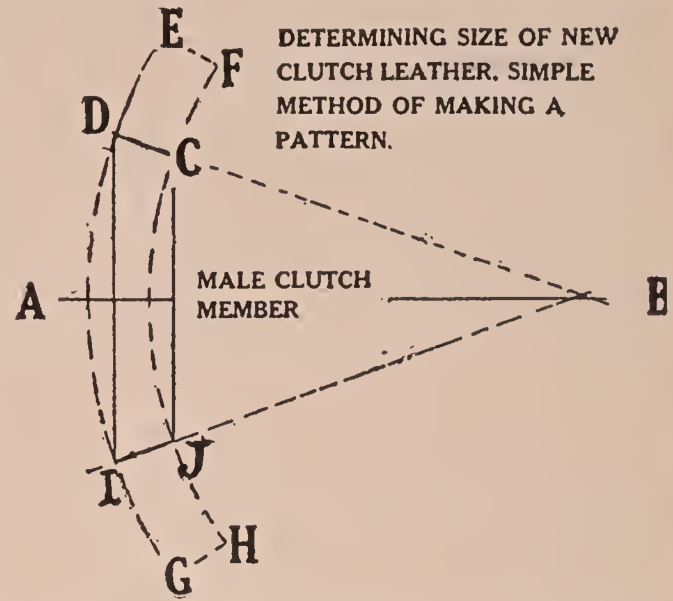


Fig. 46—Method of laying out a clutch lining, using the measurements indicated in Fig. 45.

Having cut out the leather, or heat-proof material, whichever be used, to this shape and size, one end is held firmly in place and a pair of rivet holes drilled through, and the rivets put in and clinched over. Then the lining is stretched tight with the clamps, as described for the brake lining, alternately stretching and putting in two rivets, then restretching and putting in more rivets. The result will be a neat and workmanlike job, of which the driver will be proud. Over and above this, the application of the clutch and its withdrawal will be accomplished with an ease and smoothness which cannot be had with a poorly fitted, carelessly cut or improperly applied lining. When one considers the thousands of times a clutch is withdrawn and put back in during the course of a day's driving, it seems well worth while to take an hour or so extra, when fitting a new surface to the clutch, in order to do a job as nearly perfect as possible.

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can not be done, although an expert workman can make a shaft so straight that it will not give any more trouble from this cause. This is the principal point, rather than the exactness of the shaft.

**207A. In such a case, isn't the shaft more liable to bend again and bend more easily?** Yes, a shaft which has been bent and straightened is weakened by the double bending, and is liable to bend again more easily than the first time. Should this happen, it will be an economy to replace the shaft with a new one, at the time of the second bend, rather than take a chance on this happening a third time, which it is almost certain to do.

**208A. Can a flywheel cause a knock?** Yes, if the flywheel is loose on its shaft there will be a dull pounding noise every time the clutch is thrown out or in.

**209A. How is this pounding located?** It is easily located because it occurs only when the clutch is thrown in or out, and when the engine is checked or speeded up very suddenly. When the flywheel is suspected of causing a pound, it is necessary only to get into the seat with the floor boards up, and pull the throttle wide open very quickly. If the pound occurs, close it off again just as quickly. Then if it happens speed the engine up slowly to a fairly high speed and throw the clutch out. If it occurs then, wait a minute and throw the clutch in again as quickly as possible, that is, take your foot off the pedal and let it drop in at once. If the pound occur then, and coming distinctly from the neighborhood of the flywheel this may be considered as the cause.

**210A. What causes this?** When the clutch is thrown in, this puts a drag on the flywheel in one direction, and the unit will move as far as the looseness allows. When the clutch is thrown out, this drag is removed and the flywheel will move suddenly in the other direction as far as the looseness admits.

**211A. What is the best way to remedy this?** Take the flywheel off, and in doing so, find out what the looseness is and where. If it is loose on the end of the shaft, a small, thin bushing will remedy that. If it is loose on the flange, a thin bushing of steel will remedy that. If it is too thin to straddle the flange, a flat filler ring may be obtained from a machine shop to take up the difference. If the hub is cracked, this means a new flywheel. If nothing is found, it is a fair inference that the bolts or locking means were loose. Put it back on, taking great pains to pull bolts or locking means up very tight, and then try it to see if a pound will occur. As a very exceptional cause of such a pound, the flywheel may be poorly balanced, and the unbalanced weight on one side may have worn all the bolt holes slightly oval, so that the trouble lies there. The immediate remedy is to fasten the bolts up more tightly. A better plan is to have all holes bored out larger and new bolts of a larger size fitted to them. This also will allow of fastening the unit in place more tightly. The better plan is to have the flywheel rebalanced, and then new bolts fitted.

# CHAPTER IV.

# Clutch Brake and Frame Repairs.

A REPAIR JOB which the average driver will not encounter often, but one which might come up at any time and which will need careful attention when it does, is that of frame trouble. This may be of two kinds: Natural sag, due to overloading or a weak construction originally, and accidental breakage or bending. Under the latter might come spreading apart of the side members, which would tend to disturb parts of the car hung from them and from them only. In addition, there would be the case of a side-frame member which had shown weakness of section and needed stiffening up. Thus, referring to Fig. 47, this shows a section through an ordinary channel-section side-frame member, with the short flange characteristic of American frames as contrasted with foreign ones, which have a width about twice that shown here. The fact cannot be overlooked that this additional metal and the extra stiffness which it gives has much to do with the small number of frame failures noted on foreign machines.

In this particular case, the vertical member has shown weakness, and the idea is to strengthen it. The method shown at *A* is the cutting of a strip of metal equal to the inside of the *channel* in depth and the forcing of this into place as far as possible, holding it there by means of numerous rivets through the outer member. This is a very poor and weak repair. The shape of the *filler piece* put in to strengthen is such that loading upon the top of the frame would tend to spring it out of place, were it not for the rivets. This places the latter in *tension,* which is a *stress* they are not fitted to withstand, this being resisted by the heads of the rivets only. Consequently, there is a very small surface to resist, and they soon fail; those in the middle first, and the end ones later. This done, the plate is loose and soon springs out.

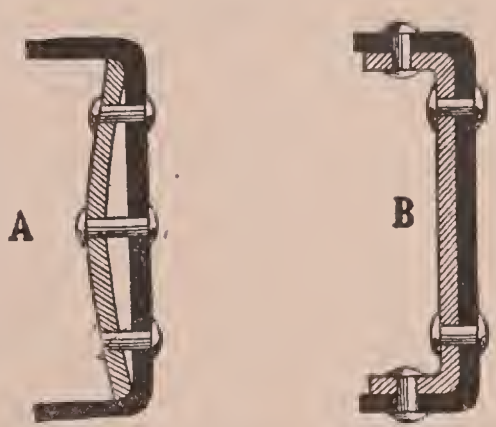

Fig. 47—Two methods of repairing a broken or reinforcing a weak frame; at A incorrect, at B correct way.

A better repair for trouble of this sort is that shown at *B,* where a plate of much thinner metal has been formed to fit the inside of the channel as closely as

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### How to Remedy the Most Common Automobile Troubles

**138. What are the most common frame troubles?** Those in which a part of the frame is so badly bent, twisted or warped as to interfere with the action of some important unit.

**139. What is a good instance of this?** The twisting or bending of the front end of the frame to such an extent as to cause the radiator to leak more rapidly than is practical to keep refilled. Such a twist may be brought about by any ordinary collision.

**140. How can this be remedied?** If not very bad, the motorist may be able to twist it back again. First remove the radiator, then note just what the twist is, where it is worst, and where least, then what part of it affects the radiator. Then do only enough work upon it to permit of using the radiator until a repair shop is reached.

**141. Are frame troubles numerous?** No; very infrequent on the modern car with its big sections, wide flanges, frequent stiffeners, and general good design and materials. But the early American cars had very many frames which were too light, of too weak material, not stiffened enough, or otherwise were not up to their work. As a consequence, old cars seldom come out of a collision or other accident without some frame damage.

**142. Are frame troubles serious?** Not unless the frame is broken or twisted entirely out of shape. This makes it impossible to use the car, but neither case is beyond repairing. By means of the autogenous welding process, a broken frame may be welded without taking anything off of or out of it, beyond clean- at the break. Similarly, if the material in the frame was good originally, no matter

possible, after which it is put in place and hammered out into an even closer fit. When fitted all over, it is riveted both at the top and bottom, and also at the side. Failure of the rivets along the top would do practically no harm, nor would the failure of those along the bottom alone, or those along the side. To make this job worthless, all of the rivets—top, bottom, and side—will have to fail, since there is practically no force to be exerted which could cause this. While held in position, the inner or repair plate holds the frame channel as stiffly as could be expected, rendering it stronger in every direction and able to sustain a much greater load. In particular, the projecting flange members are rendered much more stiff in two ways: First, the thickness of metal is almost doubled, and, second, the amount of the projection beyond solid metal or the unsupported length of the flange has been made less by the metal added on the inside. In respect to the strength of the central portion, too, this has been doubled in thickness, while the central depth between the solid metal of the flanges has been reduced by the double thickness added, half at the top and half at the bottom. In actual practice, the rivets shown would not be placed in one vertical line anywhere in the length of the frame, but would be *staggered* as much as possible, so that at any one vertical line drawn across the frame there would not be more than one hole drilled through it. This, too, is done to preserve the strength as the holes weaken the frame, and a row of four or more like the figure shows would make a considerable difference in its strength.

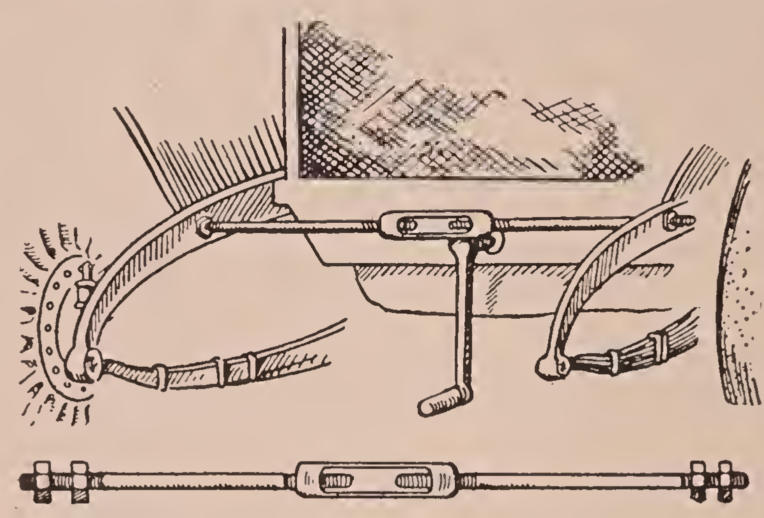

Fig. 48—How weak, spread or badly bent front frame members may be drawn together and held firmly.

The other case cited was that in which a car had been struck in a collision or had been driven into some object itself, resulting in bending the forward parts of the frame apart. As the engine and radiator were carried upon these, it was necessary to bring them back into their former relation and hold them there. The method adopted in this repair was the use of a pair of bolts with a *turnbuckle* to draw them up close, as shown in Fig. 48. The bolts were each made equal to half the width of the frame outside, plus an inch or two, and threaded at each end for about 2 inches. These were put in from the inside, screwing in one until almost to the ends of the threads, then screwing the turnbuckle on the other end of this as far as possible and screwing the other rod into the other end of the 'buckle. Then the latter was screwed out again and into the frame, but not before a nut has been screwed onto the rod. Similarly with the other end, a nut was screwed onto its outer end (at the frame) before it was screwed into place.

With both in place, a *washer* and nut were placed on the end of each rod outside of the frame. Then it was but a question of pulling up on the turnbuckle until the frame was drawn together as much as was desired. Since a long bar can be shoved into the turnbuckle slot for tightening it, a tremendous leverage

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how badly it was bent or twisted, by taking all units out of and off of it, it may be restored to its original shape. In a case of this sort, however, it is advisable generally to put on an additional brace at the point where the frame suffered the biggest bend, and, consequently, the biggest rebending to restore it to shape.

**143. If a frame sags in the middle, due to overloading or lack of stiffness, due to a small section, how can this be remedied?** One good way is to remove all units, turn the frame over, and bend it back to a straight line and a very slight amount more—that is, give it a small amount of upward sag. Then put a truss rod below the main frame on both sides with a turnbuckle adjustment. Any capable mechanic can do this, and the expense is slight.

**144. If, after a repair of this kind, when the car is reassembled and put back into use, it starts to sag again, what should be done?** The turnbuckles should be tightened up. Then if the sagging continues, tighten them more. If a continued tightening does no good, this shows that the frame is too poor to be made usable by means of a truss rod alone. It needs other strengthening.

**145. How is it possible, sometimes, to strengthen a weak frame?** By having made what is practically another smaller section frame, forcing this inside the original, and fastening it there permanently. This will

may be gained and a most unusual pull exerted. If the fitting is well and carefully done, the frame may be drawn any amount. When well tightened up in this manner, it cannot spread again, and, moreover, it cannot be driven together, the inner nuts preventing this.

A frame repair effected by a driver with no tools other than a *wrench* is indicated in Fig. 49, and this hint may be of service to other motorists. A collision bent the front cross member of the frame—in this case, a short, stiff angle—with another lighter but larger angle attached to it so as to form a channel shape. As the radiator rested upon the upper surface of the former, the water system was out of commission until this could be strengthened. The motorist had no tools with him other than a pair of pliers and a good-sized wrench. Hunting up a small wooden beam or scantling and some old wire, the wrench was wired to this so that the jaws could still be opened and closed by turning the screw.

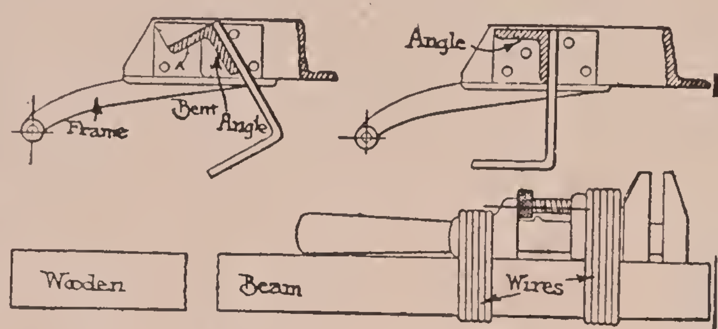

Fig. 49—Method by which a frame was bent back into place so the car could be operated, with no other tool than a wrench.

With the pliers, this wire was twisted on very tightly, and then the motorist was ready to bend the angle. The long beam gave him a leverage which he could not get with the wrench alone, while the wrench jaws allowed gripping the angle, which could not have been done with beam alone. The jaws were set to fit the legs of the angle as closely as possible, and then were slid over the upper one. A strong pull toward the rear of the car brought this up so near flush that the radiator could be put back on in a normal position. The latter was then connected up and filled, and the journey resumed as far as the nearest garage, where proper tools and equipment were available for repairing and putting both frame and radiator in first-class shape. This serves to show what a motorist can do in an emergency if he will but apply good common sense to his troubles.

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**THE EQUIPMENT OF WHEELS,** rims, or tires does not satisfy many car owners. In this there is a chance for considerable changing, some of it at no expense, other parts at slight cost, and still others go into a great deal of money. When it is a matter of tires alone, the trouble may be remedied at little cost by the purchase and fitting of *oversize* tires, as they are called. These are odd sizes, which are intended to go on the same rims. They cost but little more than the standard or regular sizes, and will take the same inner tube (although a larger tube is recommended), so that only the outer casing or shoe need be purchased to make the change. By doing this at a time when a new shoe is needed anyhow, the only extra expense lies in the difference in cost between the regular and the oversize tires.

The larger size should have a higher internal pressure, but the majority of owners who make this change do not inflate to any higher pressure than with the regular size, and take out the difference in greater comfort of riding with the same tire pressure as in larger tires. In general, oversizes run (in almost all

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make what is practically a double frame, with a strength almost double that of the original.

**146. What is the biggest disadvantage of small tires?** When the tires are too small for the weight they must carry, they wear out much more rapidly than when properly proportioned to their load.

**147. Is there any other disadvantage?** While running, they heat up more quickly, consequently there are more blowouts, punctures and other tire troubles.

**148. What is the remedy for this?** Changing to oversize tires.

**149. What are they?** Larger tires made to fit the same rims, so that they may be bought and put in the place of the smaller ones without trouble.

**150. How much larger are they?** One inch in diameter and ½ inch more in cross section.

**151. Are oversize tires made in larger diameters but not of larger cross section?** These sizes are made but will not fit the same rims, so that any change other than the 1 inch in diameter and ½ inch in cross section cannot be made without changing rims, which usually means new wheels as well.

**152. Is there any advantage in oversize tires, when the sizes on the car are large enough?** Yes; they give a bigger margin of safety, and consequently will wear longer with less trouble. Another advantage of which many owners take advantage; larger tires have the same carrying capacity with a less air pressure. Consequently, by changing to an over-

standard makes) one-half (½) inch larger in cross section, and one (1) inch larger in diameter. That is, the oversize for any regular size is found by adding an inch (1 in.) to the diameter and one-half inch (½ in.) to the cross section. Taking offhand any size, as 30 x 3, the oversize for this is 31 x 3½. Again, 34 x 4 has the oversize 35 x 4½.

As oversize tires are made in fairly complete lists of the more popular sizes by all the more prominent makers, it is possible to make a change from one make which has not proven satisfactory to another which has a better reputation at the same time the gain in diameter and cross section is made. Sometimes this change of maker is worth a good deal to a car owner who has lost all faith in the make he is using, but hesitates to change to another because of the considerable expense which a whole new set means.

In the matter of effecting the *speed* of the car, the difference in a regular and an oversize tire is so slight that no difference can be noted one way or the other. In theory, the change would tend to speed the car up in the *ratio* of the two *diameters*. That is, the engine at its maximum speed could produce but so many turns, while with positive gearing between it and the rear axle the latter would be turned over just so many turns. If the axle were sure of this number of turns, no matter what sized wheels it carried, increasing the outside wheel diameter without increasing the car weight materially or offering no additional resistance (as in the change to oversize tires) would give more speed since larger wheels turned at equal speed produce a greater distance of travel in the same period of time.

As the gain in circumference is but 3.14 inches in each case, in percentage this is but 3.24 for the 30-inch tires and 2.95 for the 34s. Based on a speed of 40 miles an hour in the first case, this would raise the limit to 41.3, and based on 50 m.p.h. in the second instance, the change would raise the speed to 51.5. That is, as stated previously, the difference in speed is not noticeable.

Herewith is given a table which shows the various oversize tires as made by the different firms. As has been stated previously, there is more or less of a standard, in which the tire diameter is increased by 1 inch and its cross section by ½ inch; but a few firms make other oversize tires, differing from this standard. With those exceptions, the list chronicles those makers whose product may be obtained in the oversize sizes against which their names are given. This is in amplification of the remark previously made to the effect that when dissatisfied with a make of tires, the purchase of oversizes gives a good opportunity to make a change of makers also. Reading across the table in a horizontal line will be found all the makers who produce that particular oversize size listed at the left-hand end.

In a rough and somewhat incomplete manner, this represents a standard list of tires in the oversizes, while it may be said that a somewhat similar situation exists in regard to tire dimensions in the standard sizes. That is to say, all tires made to a certain size—as, for instance, 34 x 4—will not be interchangeable upon the rims with which the car is fitted, although the majority of them will.

With regard to rims, however, little can be said. Previous to 1911, the rim

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size, the owner need not inflate his tires as hard, and the car will ride easier and softer.

**153. Will the change of 1 inch in diameter affect the speed at all?** Practically none. While in theory the circumference will be increased by 3 1-7 inches, this is such a small percentage of the whole circumference as to be negligible. In theory, the car should travel slightly faster, as with no greater weight and no change in the gearing the same motor will develop the same horsepower at the same speed. This means that the wheels will be turned at the same speed as the smaller ones—that is, an equal number of revolutions a minute. If the circumference is greater, the car should travel a longer distance for each revolution of the wheels—that is, its speed in miles an hour should be slightly greater at the same engine speed.

**154. Why is not this theory proven out in practice?** In part, because with oversized instead of undersized tires, the average owner will not be insistent on a high air pressure. This means that the larger size, which is wider to begin with, will present a wider surface in contact with the ground. As this condition has a large bearing on the speed of the car, and as each very slight increase in the tire surface which contacts with the ground is multiplied by four, the total is quite considerable.

**155. What is the function of the inner tube?** To hold the air only. It does not offer any resistance to wear or do anything else. It is

situation was chaotic, but in that year a strong movement for standardization and unification of the various and sundry rim sizes was begun. Due also to the strong grip on the rim situation exerted by a few big makers, some progress has been made, but this has been nullified in part by the springing up all over the country of inventors of demountable rims. With regard to the older forms—namely, the *straight side* or *Dunlop* tire, the *clincher* and the *quick-detachable clincher*—considerable progress has been made, and the majority of rims made for these types of tires, even of different makes, will agree in the main, enough so as to be interchangeable. It may be added that the Society of Automobile Engineers is now investigating this situation, previous to the adoption of standard sizes and specific dimensions, the adoption of which will bring about the long-desired unification of the industry on this point.

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**TIRE REPAIRS** present a wide field for the amateur driver who is deeply interested. The common idea of pneumatic tires is formed from observing them fully inflated and thus practically *solid* to the touch or to the casual blow. From this many persons who know little of the construction of tires think of them as being solid or at least as fully as solid as wood or similar familiar materials. With this thought firmly implanted on their minds, they treat the tire about as they would one made of wood or similar materials at all times. This is so far removed from the actual case as to be ridiculous, for rubber is just as delicate and needs just as much care and attention when inflated to a pressure which makes it appear solid like wood as when entirely deflated or when handled as an empty inner tube only.

This cannot be emphasized too strongly; rubber itself simply forms an *envelope* which retains the air pressure, and it is the latter which supports the car and upon which its occupants ride. The rubber is simply a container, for convenience sake, made with an inner tube of pure rubber and consequently very flexible and yielding and an outer casing not flexible and only slightly yielding but of a composition and so constructed as to withstand the wear of road shocks and obstacles as much as possible.

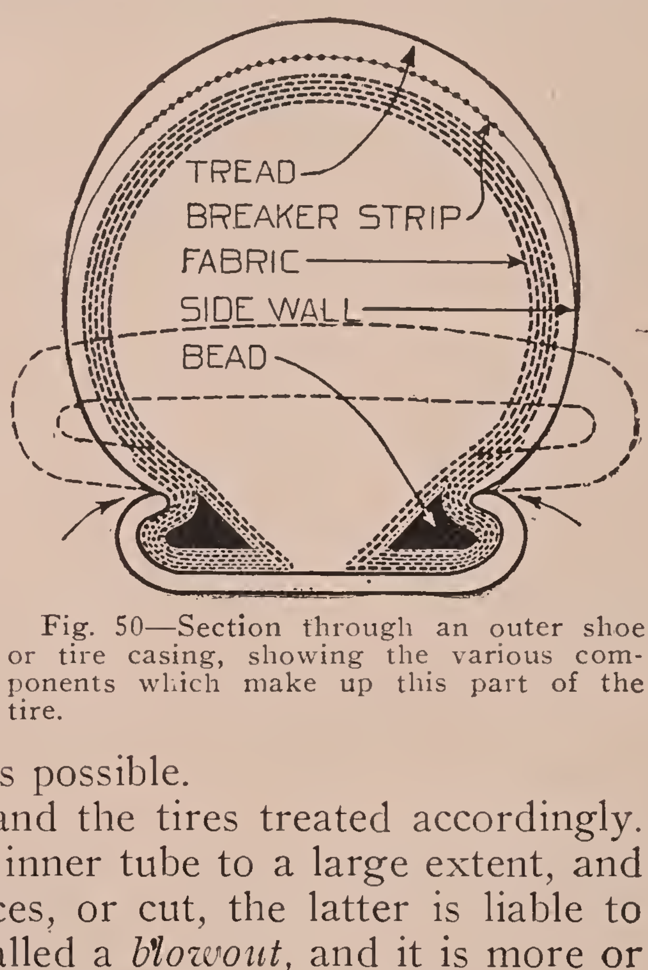

Fig. 50—Section through an outer shoe or tire casing, showing the various components which make up this part of the tire.

This should be borne in mind at all times and the tires treated accordingly. Thus the wearing portion or casing protects the inner tube to a large extent, and if the former be badly worn, opened up in places, or cut, the latter is liable to burst through these. When this happens, it is called a *blowout,* and it is more or less serious, for it means a new tube and new casing generally. In addition, someone may be injured by the flying rubber, while another source of personal damage lies in the fact that the driver has difficulty in controlling a car with a flat tire

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simply a flexible air bag of nearly pure rubber.

**156. What is the function of the casing or shoe?** To supply a wearing surface, to protect and enclose the delicate inner tube, and generally do all the hard, heavy work the tire is called on for. It contains very little pure rubber, being generally a compromise between the compound which gives the greatest resiliency and the one which gives the greatest wear or longest mileage. Some casings which wear very long do not possess much resilience, whatever the internal air pressure, while others of the highest resilience do not have a very long life.

**157. What is the function of the so-called Q D rim?** To make tire changing easier than with the older clincher type of tire. Moreover, the clincher method of putting on and taking off tires is hard on the tires themselves, and if a person had many punctures, the shoe was practically ruined taking it off and putting it on again.

**158. What other advantages has the Q D form?** Besides making tire changing quicker and easier, for both operator and tire, it allows of using both the old Dunlop form of tire and the clincher form on the same rim by simply turning over the ring.

**159. What advantages does the Dunlop style of tire possess?** For equal sizes, the Dunlop has the highest percentage of air space; some makes have 15 per cent. more air space in a Dunlop type than in the same size of

when going at high speeds. Thus the machine may swerve after a blowout and go over a road embankment into a deep ditch or cause other trouble.

In order to present the essential parts of a tire more clearly, Fig. 50 is given. This shows a section through a typical clincher tire, the tube being left out in order to make the construction more clear. At the top will be seen the outer surface or tread, which is of a tough, hard wearing composition, containing a small amount of rubber—that is, small compared with the inner tube. Next below this, imbedded in the lower portion of the same, will be found a single layer of a tough fabric called the *breaker strip*. This is composed of a strong *cotton fabric* which has been surfaced with rubber on both sides and the same rolled into its pores. Its function is to reinforce the *tread*, to give notice to its user that the tire is wearing out, and lastly to prevent, in part, what are known as *stone bruises*, in which the impact with a stone or other road obstruction breaks in permanently a section of the tire surface, although this may not be apparent on the exterior.

**THIS BREAKER STRIP** marks also the lower limit of the so-called tread rubber and the upper limit of the outer coating of rubber. The latter tapers from the *bead* or projection at the base of the tire in thickness up to the middle of the top, the portion from the two sides being approximately equal to that at the top. This also is a composition, but containing slightly more pure rubber than the actual tread. In the drawing it is marked *side wall.*

Beneath it will be found the fabric; in this case, five layers of it. This is composed of the finest cotton cloth woven from specially long fibered cotton, and is known for its great strength and durability. It forms the basis of the tire upon which the other materials are hung, so to speak; in fact, in the trade the completed fabric portion is known as the *carcass*. This frictioned fabric is all laid up very carefully so as to *overlap* or break joints, thus no weak spots are left. The beads are formed from a more solid composition, around which the fabric is wound, thus enclosing the rubber. The object of these is to retain the tire on the rim, for which purpose they are made of a shape to fit the rim upon which the tire is to be used and of a size and shape to yield the corresponding strength and rigidity needed.

It will be noted, however, that no matter how stiff and strong the bead itself may be, it is joined to the upper portion of the tire by the thicknesses of fabric only. When a tire is used deflated, as in case a puncture is suffered when

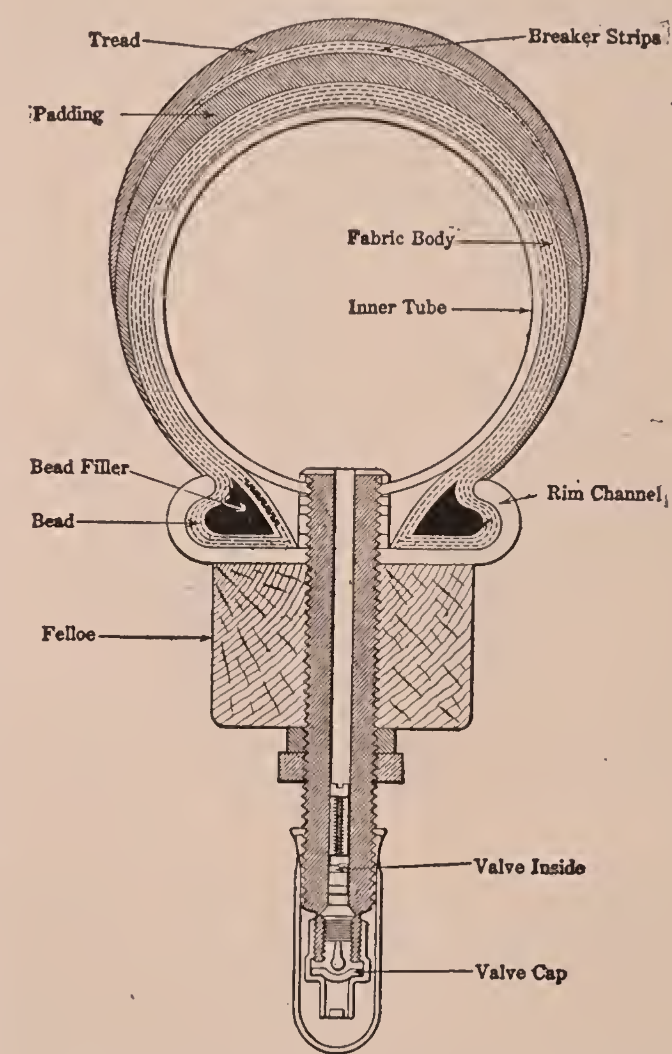


Fig. 51—Another tire section, showing all casing parts, as well as an inner tube in place and a section through the valve.

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tire in clincher, Q D, or other forms. In addition, it is easier to put on and take off than any other form. The weight of the double bead is saved, so that with this form there is less flywheel effect in the rotation of the wheels because of the slightly lessened weight.

**160. What is the advantage of the demountable rim?** This allows of taking off the tire as a whole, and replacing it with another rim carrying its complete and inflated tire. In this way the work of taking off locking and retaining rings, shoe and tube, patching, replacing, and other work incidental to a puncture or blowout is reduced to the more simple and quicker job of changing from one wheel which has been put out of business temporarily to another perfect one. It necessitates having five or more tires and carrying one of them, mounted on an extra rim, with tube in place and inflated all ready for use.

**161. How can valve leakage be detected?** Run the wheel into a puddle of water deep enough to cover the top of the valve. Then the weight of the car will force the air out through the water, this showing by means of air bubbles.

**162. Is there any other way?** Raise a tumbler of water from below until the valve is entirely immersed in the water. Then the leak, if any, may be observed with ease.

**163. What is the remedy for a leaking valve?** If a nearly new one, screw it down tighter, or take it out and see if there is any foreign

no repair outfit is handy, and the motorist decides to run home on the rim, the upper portion of the tire is flattened down by the weight of the car so that it assumes the position shown by the dotted lines. It will be noted that then the upper surface of the rim is pressed into the fabric at the points just mentioned where the tire is weakest. This, continued for any length of time, will cut through the few layers of unprotected fabric, this being known as *rim cutting*. When this has been started, too, it cannot be stopped or repaired in any manner. Carried to an extreme, the fabric is cut entirely through, and is rendered useless except as a surface covering to lengthen the life of an old shoe which has a good bead and lower portion.

An even better section of a tire is that shown in Fig. 51, in which the inner tube is seen in place, while the *valve* is shown in section and the *felloe* or wooden rim of the wheel is sectioned also. Here the tire construction previously mentioned is shown with more clearness, while it will be noted how the inflated inner tube fills out the casing. The fabric of bead and tread portions is brought out clearly, as well as the packing layer and its peculiar shape, also the breaker strip and the tread. The manner in which the rim fits the felloe will be noted, also the construction of the valve which appears to be screwed through it; in reality, it passes through a hole of sufficient diameter to permit it to be pushed in and out every time a puncture must be repaired or the tube be removed for other reason.

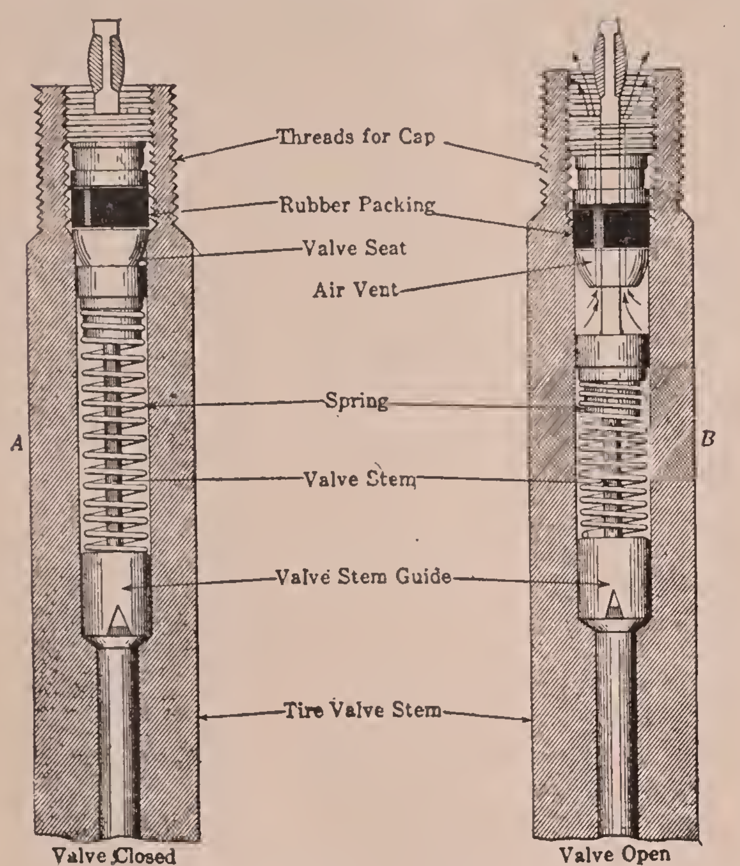


Fig. 52—The parts of the tire valve and how they work; section showing the construction.

Another suggestion is that the *dust cap* should be made longer and connected to the *retaining nut* at the base marked *A*. This is the more usual case; in fact, the latter is made an integral portion of the dust cap and provided with wings so that it may be screwed on and off, using only the fingers to tighten or loosen it. This sketch shows plainly the interior construction of the common or *Schrader valve* for tires, but not in as much detail as would seem desirable.

To remedy this, Fig. 52 presents this in larger sizes. Here the left-hand view or *A* shows the valve closed, while the right-hand sketch or *B* presents the same open. This shows how the valve seat is solid and rests against the tapered portion of the stem permanently, the contact being made by the *rubber packing*. The valve seat, however, is made with a large central hole, of which the valve stem occupies but half. Within the lower part of the valve a plunger is held up against the bottom of this valve seat by means of a *spring*, this being a fairly loose fit in the hole through the stem at that point. So long as its upper part or plunger is

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matter on the valve seat. If neither course helps the matter of leakage, screw it out and put in another. Every motorist should buy a card of these consisting of a dozen at the beginning of the season, and carry them with him at all times. The cost is but 50 cents or at retail 5 cents apiece.

**164. How can these valves be screwed down or out?** The ordinary screw driver is too large, and the stem portion in the middle of the valve interferes with its use, anyhow. Many drivers cut a small notch in the middle of the bottom of the blade of a screw driver small enough to go into the valve stem. This does not harm the screw driver for other uses, and makes it applicable for tire valve work. A better plan is to buy one of the valve stem tools, so called. These have a screw driver for valves on one end, a tap for recutting damaged inner tire valve threads on the other, and a die for cutting the outer threads of the tire valve stem somewhere else. Thus they have a threefold use.

**165. How much should tires be inflated?** This depends upon the weight of the car, whether heavy or light for its tire equipment, the weather and time of year, whether exceedingly hot, freezing cold or just moderate, upon the condition of the tires, whether new and reliable or old, nearly worn out and doubtful, and upon other things.

**166. In general, what is a good rule?** From 17 to 18 pounds of pressure for fronts and 20 pounds pressure for rears, for each inch of

held tightly against the valve seat, however, no air can escape, but as soon as the plunger is pressed down, the air which presses against it from below can pass around its interior into the central portion and thence out through the *annular hole* around the stem. The arrows indicate such passage of air in the right-hand view. In looking at this pair of drawings, it is apparent that when the valve leaks there are two methods of remedying this: One, the upper portion of the seat may be screwed down farther so that it meets the plunger at a lower point, which is equivalent to giving the spring more tension, and, thus, should hold tighter; or else the valve may be removed and the spring lengthened, a piece put under its lower end to increase the pressure which it exerts, or a new spring entirely and a stiffer one, put in its place. Attention is called to one point which might be misleading, namely, that in the right-hand figure the packing and valve are screwed down quite a little farther than in the left-hand view. This is likely to be misleading when one attempts to compare the two views. Actually, the two should be alike in this respect.

**LOCATING VALVE LEAKAGE.**

Reference has been made to valve *leakage*. This is a very difficult thing to find when the leak is very small so that often the air will not leak down to a point where the leak is noticeable for a week or more, even when using the car continuously. A plan for finding the leak rather quickly is the insertion of the valve stem in *water*, when the tire is pumped up quite hard. The trouble will show in an instant by the *air bubbles* passing through the water.

The method of doing this is to turn the wheel so that the valve comes at the highest point, as shown in Fig. 53. Then a common tumbler is filled as full of water as is possible and held by hand between the spokes and gradually raised until the entire valve right up to the felloe is submerged in the water. By holding it in the position shown for a few moments, or even a few seconds, a large leak will show itself beyond question. If the leak is a very small one, it may require close attention, in which case it is well to hold the valve in the water for a longer time.

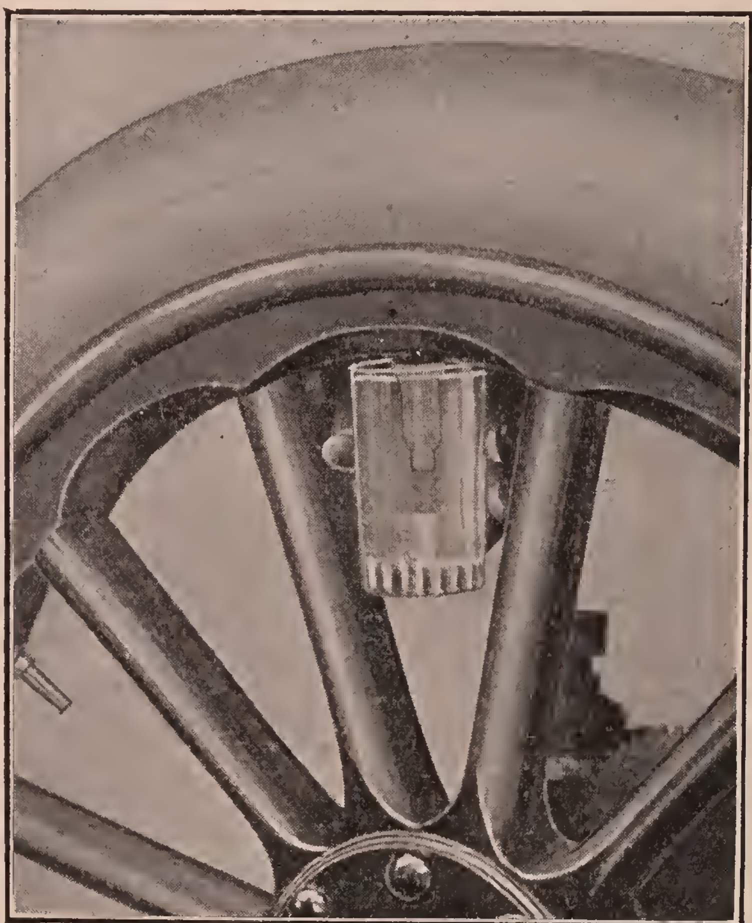

Fig. 53—Simple but very effective method of determining whether or not a tire valve leaks.

**FULL-SIZE TIRES.**

It is highly important in using tires to know that they are of full size and sufficiently *inflated*. The former is more or less important, because

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tire width. Thus, with 4-inch tires 72 pounds pressure in front and 80 in the rear; for 4½-inch tires, 81 and 90 respectively. This should be varied to suit car, weather, season and tire conditions. Another good rule for an experienced motorist to use is to pump them up just so they stand up round and full under their load, regardless of the exact pressure used. Since this will vary with the weight, the tires, the temperature and other items, it is a fairly flexible rule.

**167. When the tires wear faster on the sides than anywhere else, what is the trouble?** They are probably out of true, so that one set, that is the rears, does not track exactly with the other, the fronts. Either pair may be at fault, but the net result is that a pair of tires is being dragged or pushed (as the case may be) in a direction against the center line of the tire. The result is wear on the sides instead of the treads which is normal.

**168. Are there other causes than lack of alignment for this?** Yes, if confined to one particular wheel, some projecting part may be rubbing against the side which shows wear. Or the driver may be in the habit of driving a great deal up close to the curbstones, so that the tires are rubbed off in this manner. Another possible source of side wear is running in the car tracks when the rails happen to be set very high above the road surface.

a tire which is undersize is very likely to have been skimped somewhere else, so that trouble may be looked for anywhere and at any time. To measure this, no special apparatus is necessary, a simple variable cross or L shape being all that is necessary for the diameter, while a pair of *calipers* in a large size will answer for the cross section. The former operation is shown at *A*, Fig. 54, the prerequisite being that the tire be well inflated and raised so as to touch the ground or floor at a single point. If this be not done, the weight of the car will flatten the tire and prevent a correct measurement.

Lifting the wheel clear of the ground will not answer, for then it becomes necessary to tamke two measurements, one to the bottom of the tire and the other to the top. As the rounding surface makes one of these difficult enough to get with accuracy, two will simply make the job more difficult. When measuring from the ground, as shown in the figure, the cross arm is raised until it just touches the top of the inflated tire, when it is clamped in position and later measured with accuracy. In taking the cross section measurement, as shown at *B*, Fig. 54, the calipers are widened out gradually until they will just go on over the side of the tire in a vertical plane at right angles to the plane of the wheel. When less than the correct amount, the calipers may be squeezed over the sides of the tire, and when oversize they will pass it without touching it. What is wanted is a mean, in which they need not be squeezed over on the one hand nor widened out to pass without touching on the other. When this has been obtained, it is translated into inches by applying the clamped calipers to a steel scale or any standard measure.

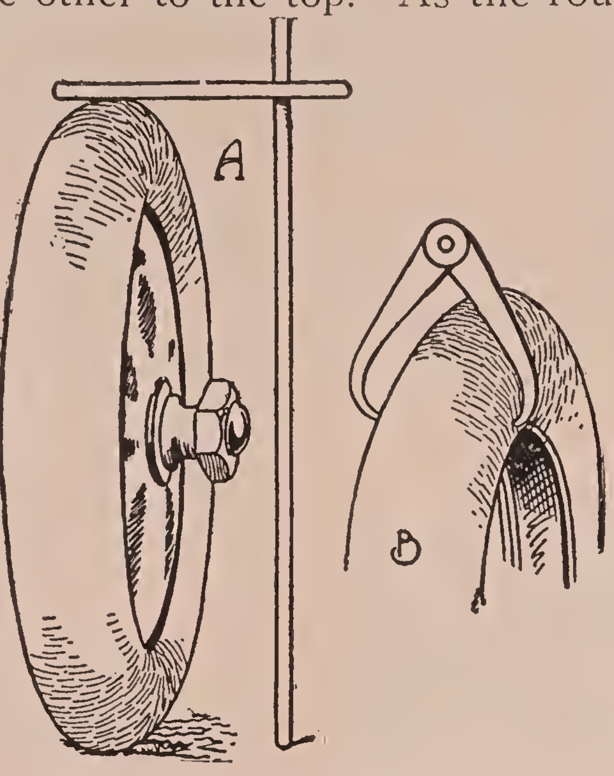

Fig. 54—Measuring the tire to see if it is of the correct size and shape, otherwise it is defective.

**AS TO INFLATION PRESSURES,** the different companies disagree slightly, but the following (Table II) represents good practice, and may be used with safety. In general, the maximum pressure recommended by manufacturers, while it will give long life to the tires and prevent rim cutting and similar troubles, is a little too hard for comfort with a small number of passengers in the car and is somewhat liable to bring on blowout troubles when the tires are old and worn. For this reason, many drivers make a practice of running about 5 pounds under the maker's recommendations in cold weather and 10 pounds under in hot weather.

Anyone who has ever ridden a bicycle and been obliged to repair a puncture of the tires knows how to repair a puncture on an automobile tire. Simply remove the casing, then take out the tube, *patch* the hole, then replace tube and casing, reinflate, and go on your way. When it can be done without trouble or delay, vulcanizing the patch is an excellent plan, for then the patch is incorporated

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**169. How can this be done?** Set four chains on for projections, caution the driver against the other matters; then if it continues, measure up to see if the wheels are true and agree with one another.

**170. How can this be done?** Set four chairs on the floor, some distance in front of and back of the car, so that the pair in front and in back almost line up with the two pairs of wheels. Stretch a string along one side of the car, fastening it to the two chairs on that side, and similarly on the other. Gradually move the chairs in toward the tires or out, as the case may be, until the string on that side forms a straight line, exactly touching the front and rear tires at the central point—that is, just at the middle of their heights. When this has been done on both sides, measure the distance between the two strings at the front and rear. In addition, the front wheels will be found to toe in slightly; line up the string on the rear part of the front tire, and measure the amount it toes in at the front. If the two front wheels do not toe in exactly the same amount, turn the steering wheel, so that they do. Then readjust the strings to agree with this and remeasure. If the measurement at the front and that at the rear do not agree, the wheels are not true. If they agreed at first, but moving the strings to go with the toeing in of the front wheels has altered this, then the fault lies in the lack of agreement of the front and rear pairs.

into the tube and will never give any trouble, the vulcanizing process making the patched tube the same as a new one except for the added thickness of material at one point.

TABLE II.—INFLATION PRESSURES FOR TIRES.

| Sectional Size of Tires. | Inflation Pressure Recommended. | 4 Tires Will Carry in Pounds. | When Car and Passengers Weigh less than | Maximum Comfort will be Obtained with Pressure of |
|---|---|---|---|---|
| 2½ | 55 | 1,000 | 900 | 45 |
| 3 | 65 | 1,600 | 1,400 | 55 |
| 3½ | 70 | 2,000 | 1,750 | 60 |
| 4 | 75 | 2,750—3,900 | 3,300 | 68 |
| 4½ | 80 | 3,400—5,300 | 4,000 | 72 |
| 5 | 85 | 4,500—5,600 | 5,000 | 78 |
| 5½ | 90 | 5,200—6,000 | 5,400 | 83 |
| 6 | 95-100 | 5,500—7,500 | 5,800 | 90 |

**REPAIRING SURFACE TIRE CUTS**

is entirely different, however, and must be treated in a different manner. The proper method for the repair of a bad cut in a casing is to clean this, fill it with new rubber, and then vulcanize this into the older tire. To do this, proceed as follows: Clean out the cut with *gasoline,* as shown at *A,* Fig. 55, after which the edges should be trimmed up neat and clean with a sharp knife. Then with a small, stiff wire, wound with cotton, the surface below the cut—that is, the inner rubber or fabric, as the case may be, is flattened out to receive the patch, with perhaps a single indentation or two to form a *bond* with the old material.

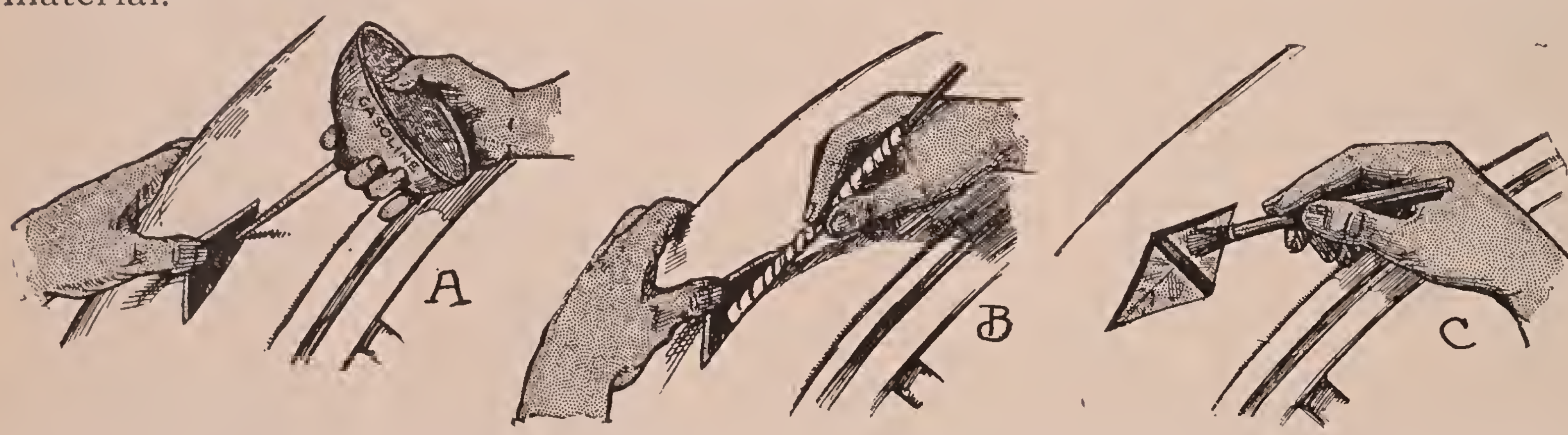


Fig. 55—Three steps in the repair of a bad cut in a tire casing. At A, cleaning the cut, at B drying it out and preparing the surface, at C coating the surface with cement.

Next, the whole surface to be patched is brushed over with a good *rubber cement,* as indicated at *C,* and the *patch,* which has been cut to size and shape previously, applied. This should be made thicker than the normal surface of the tire by about 1/16 inch, and of full width all around. When well placed in the hole, cemented down all around, the whole should be vulcanized, using care to have the right *temperature* and for the right length of time. For this purpose

**146A. The surface of the tires begin to show cross cuts at regular intervals around the surface.** This is the cutting caused by the use of chains.

**147A. How can it be avoided?** By using the chains only when needed, taking them off as soon as the need has passed, using care in putting them on so that they do not come in the same place as before, and also allowing them to float around the surface. More of the tire cutting due to chains is the fault of the driver in anchoring them in one place where they stay and soon start cutting. A secondary fault is keeping them in place long after the need for them has passed, through sheer laziness.

**148A. When this has happened, and the tread is cut clear through to the fabric in at least one place, while the cuts are very deep in a number of others, what can be done?** Retreading will save buying a new tire, but should be done only when the condition of the tire aside from this is good enough to warrant spending the necessary money for a new tread.

**149A. Can the average driver of several seasons' experience retread a tire?** No, it requires a great deal of experience in that work and a very large amount of personal skill, besides an intimate knowledge of the materials to be used.

**150A. In general, is retreading worth while?** When the tire is in such a condition generally that the driver can expect to get from 1,500 to 2,000 miles more out of it with a new tread, using reasonable care in driv-

the various makers of vulcanizers—steam, electric, gasoline, and alcohol—furnish instruction books, which tell just how long the device must be applied. This welds the patch into the older rubber so that the two are joined together as strongly as if one; in fact, when a neat and workmanlike job has been done, often it is difficult to find the new patch. Aside from the looks, what is more to the point, this patch will wear as long and as well as the old rubber on either side of it, thus strengthening the whole tire and lengthening its life and mileage.

**WORKING STANDS AND RACKS.**

When the driver finds that he likes to work around the car in its garage, or that he saves money by doing the work himself, as well as much trouble on the road, generally he begins to take more interest and does a good deal more along the same lines. Having decided to do most of his own repairing and adjusting, it is a wise plan to make a lot of *stands* and *racks* for holding the various parts conveniently when working on them. Thus, for propping the machine up off the floor so that the tires do not touch, when it is out of use during the winter or at any other times, it is useful to have a set of four small *horses* or supports. That shown in Fig. 56 is easy to make, and cheap, besides being of such a nature as lends itself well to any similar use, and not taking up a great deal of space. In shape it forms a pyramid upon a base which is like a star with four points. The latter is constructed first, the usual *scantling* material being good for this, or any 2 x 4 or 3 x 3 material. Both pieces are *notched* halfway through, the notch in each one being of width equal to the width of the other piece. These are nailed together, then the short upright, marked *C* in the dotted sketch above and *B* in the assembly, is fastened to this, being simply set upon its center and nailed there from below. This does not make a firm job, however, so four inclined pieces, one from the end of each cross arm to just below the top of the upright are used. These are shown separate at *B*, but are marked *C* in the assembly.

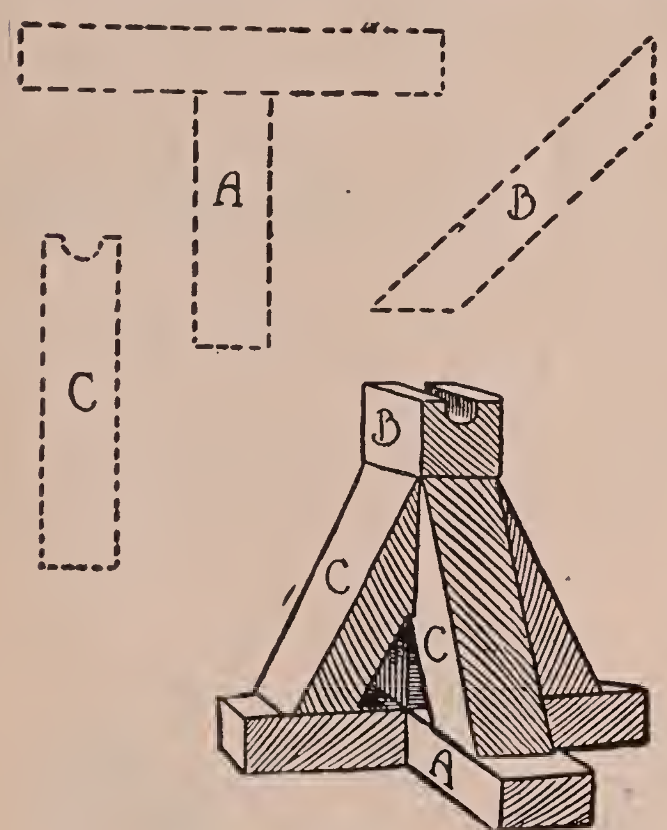

Fig. 56—A simple but very strong and effective stand which any driver can make from cheap lumber.

They are nailed firmly into the base pieces and also into the upright. Before assembling, the member *C* is notched at the top, either with a half-round notch, as shown, or a fairly deep V groove. The idea is to have a place into which anything set upon the support will fit so that there will be no danger of its rolling or falling off. When built primarily for supporting a car beneath the axles, the notches should be made to conform to the lower sides of the axles. It is best, however, to make all four alike or as nearly alike as possible, so that they may be picked up and used as they come, without the necessity for sorting them out to find which ones go here and which there.

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ing, retreading is worth while. When it is in poor condition, has worn or cut beads, weak fabric near the beads, or in any other way shows signs of an early failure, or of past hard usage, retreading is not worth while.

**151A. What is a good rule relative to this?** Examine the inside of the tire; if all the fabric appears whole and firm then examine the outside of the base portion. If this is in good condition, also, retreading is worth while if the new tread can be depended upon to give a mile for each cent expended, or under a very heavy car or one which sees hard usage, a mile for each ¾ cent. This would mean on a light car, 1,500 aditional miles for a $15 job; on a heavy car, from 1,500 miles up on a $20 job.

**152A. What is the trouble when a tire begins to show a series of ridges across the surface and on the side a lumpy appearance, supposing that there are no cuts to indicate the use of chains?** This condition indicates underinflation, that is the tires have been used when there was not enough air pressure in them.

**153A. In what other way will this be indicated?** The sides of the tire down close to the bead will be cut, possibly the outer layer of fabric there will be cut through. This is called rim cutting, because it is caused by running on the tires so poorly in-

A similar useful little member may be made the same as a *saw horse,* restricting the height, however, to about 16 inches and the length to 12 or 14 inches. For the ends, any fairly thick boards which are not too wide will answer, these being cut to lengths, while a beveled end will bring their tops together and give the necessary width at the base for a firm support. Having completed a pair of these, a piece of 2 x 4 may be nailed between them, finishing off the top by means of a flat piece of plank which will extend over the end pieces and be nailed into them as well as firmly nailed to the 2 x 4 top. If it is desired to make a better job of this, the end members may be nailed against the sides of the top member instead of being nailed together and then the top put between them. It is surprising what a large number of uses will be found for these little horses when they have been completed and are setting around the garage handy.

**FOR BIG REPAIR WORK,** such as a stand for holding an engine, transmission, clutch, or similar part, when making repairs, special stands should be made to the dimensions of these parts. For handling the body or similar bulky work, however, any well-made stand of large size will answer. In Fig. 57 a couple of these are shown at *A* and *C*. The former is built specially, and consists of a pair of ends made somewhat like the construction of a ladder. This done, a lengthwise piece on top at each side and a diagonal stiffener on either side complete the stand, which may be made very quickly. If this is to be used very much, however, it is well to make the corner posts large enough to take a castor, and then purchase four castors for this. When

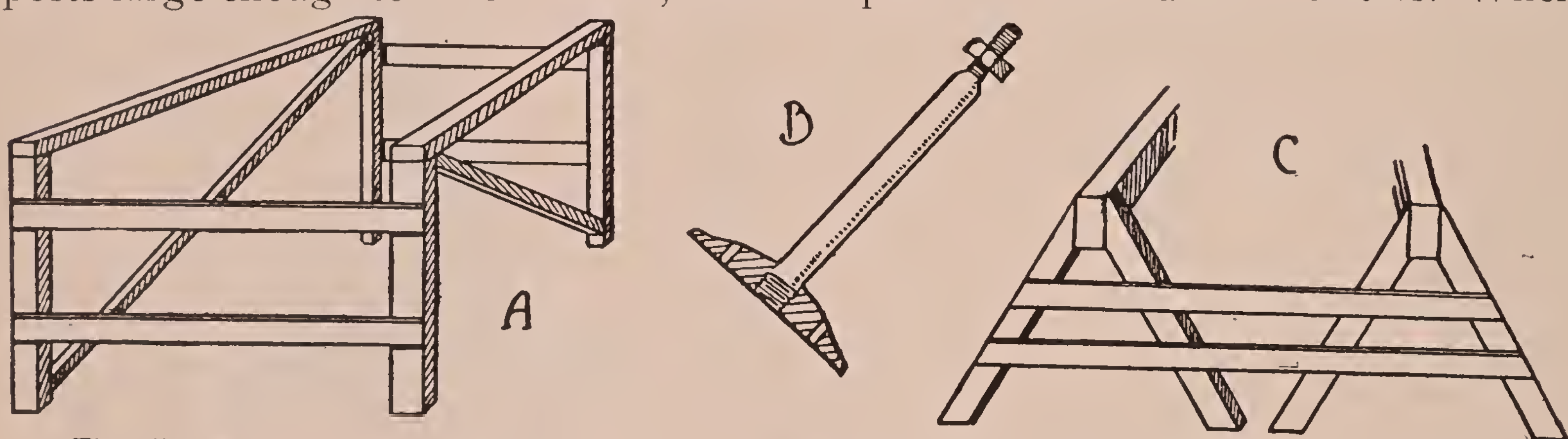


Fig. 57—More stands for convenience and labor saving in overhauling or working on the car.

one has been obliged to ask help of two or three neighbors for the purpose of lifting off a body, it is mortifying to have to go out and beg assistance again to move the stand with the body on it from one end of the garage to the other, simply because you forgot to have it placed in the latter location previously. The castors on the posts will avoid all this trouble, in addition to providing a means of turning it so as to get the best light at all times when cleaning it or doing other work upon it.

While this form is easy to make, that shown at *C* is even more easy, consisting of a pair of saw horses, which may be borrowed or bought, across the ends of which a pair of cross pieces have been nailed in order to tie the whole into a wide and firm structure. In fact, for this purpose the small car-supporting horses,

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flated that they sag down under the weight of the car until the sides which should be vertical, rest against the edges of the metal rim, and are cut by them.

**154A. What causes these lumps and ridges?** The running of the tire with too low an air pressure has loosened the tread from the fabric and it is floating around, so to speak.

**155A. How can this be fixed?** If there is no rim cutting, the time may be retreaded, but in nine cases out of ten, where there has been underinflation, the fabric is cut.

**156A. When the fabric is cut, what can be done?** Nothing, expect throw the tires away. That is, from the point of view of the tire man. The amateur driver who feels that he must get every possible mile out of his tires can cut the bead off and pick up a second tire which has a good bead all around. Then he can have his old tread stitched onto this and get enough mileage out of this, although it looks bad, to warrant the trouble and expense.

**157A. Why is it that a tire can not be repaired when the fabric is bad, as when the outer layer is rim cut clear through?** The fabric is really the tire, forming the whole foundation and strength of the construction. The rubber is merely a surface wearing part and has no strength of itself. When the foundation is weak, the whole structure is weak, no matter how good it may look from the outside. In the case of rim cutting, the three, four or five plaits of fabric along the

previously mentioned, could be used by making these connecting pieces long and stiff enough. The member shown at *B* of this figure is an adjustable bench stand, by the use of four of which the bench may be raised or lowered, as desired, in order to take care of work which is handled best, either higher or lower than in the ordinary case. Being of metal, also, they may be used to make a stand out of any platform, whether suitable for the work or not, the lower end and shoulder forming a support and a fastening means, while the broader foot forms a fine resting place for the work direct or for additional boards on which the work may be placed.

Fig. 58 shows a pair of stands as constructed by one motorist, the utility of which is evident enough to warrant copying the same. That at *A* was a stand for the engine, the width and length of the upper surface being proportioned to the width and length of the engine crankcase, bearing in mind also the shape, width and location of the supporting feet. As constructed, 4 x 4 timber was used throughout, with the single exception of the two middle end braces. The other end braces were mortised half and half into the corner posts, as were also the long side braces.

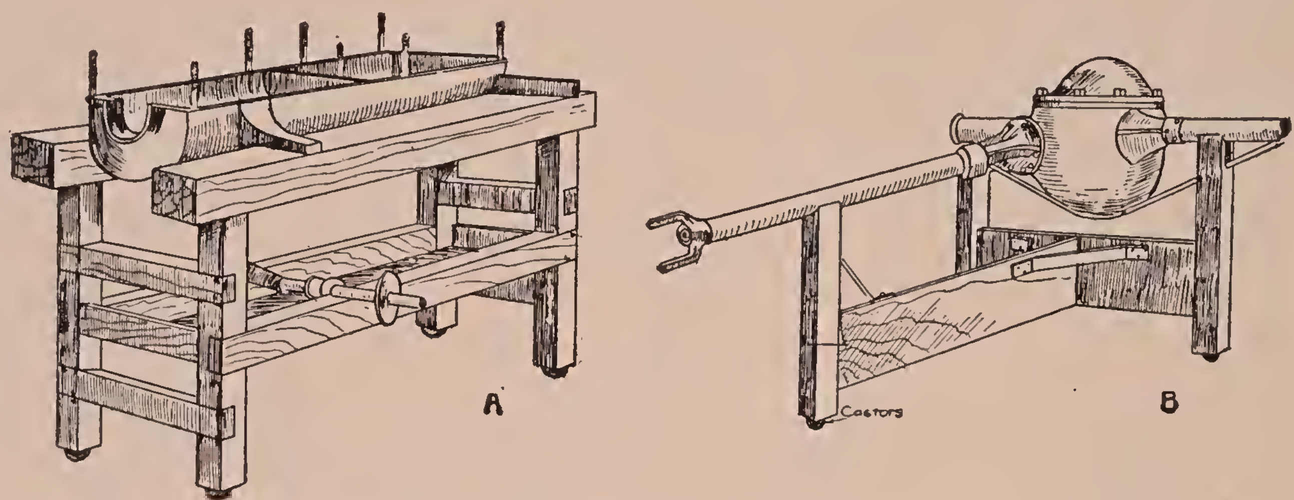

Fig. 58—A pair of homemade stands which are very useful, at A engine support, at B an axle and driving shaft stand.

The upper ends of the four posts were tenoned into the underside of the longitudinals, while their lower ends or feet were fitted with castors. So, while the whole thing was heavy, it was easy to move around, considering which its very weight was an advantage, as it kept the thing stationary until a move was necessary or desirable. As the sketch shows, the two long side braces formed an excellent shelf for long pieces which it was not desirable to take away from the crankcase, as the crankshaft or camshafts, etc. This portion of the stand might have been improved further by laying boards over the surface of these two braces to form a continuous shelf.

The other stand, as seen at *B*, was constructed to take a rear axle, differential case and driving shaft, just as they came out of the car. This rather unusual combination makes an odd-sized stand and one which looks funny. It was very useful, however. In construction it followed the other very closely, as for instance in the use of 4 x 4 timber, castors in the three legs, etc. The joining members or braces, however, were made from flat 1-inch boards, their length and the size of the whole stand making anything thicker too heavy. These were selected

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sides constitute the entire connection between the tread and the bead which holds the whole tire in place. If this connection be cut, even partly, the tread is not held firmly to the wheel and less air pressure can be used with safety. Moreover, this is a place in the tire where it is impossible to replace the fabric and give anything like the original strength.

**158A. What is a blister and what does it look like.** A blister is a swelling or lump on the surface of the tire, close to a small hole entirely through the tread. It does not resemble the lumps mentioned in the trouble above, in that this one is an individual lump and will have a semi-circular of semi-oval appearance. These lumps on the surface of the tire are entirely detached from one another, and each is more or less close to a hole in the tread, whether the latter is visible or not. They consist of a quantity of sand or dirt from the road, which has been forced in through this hole, and by the action of the car rolling on this, it has been packed in tight.

**159A. What harm does such a blister do?** The continued movement of the car pushes this hard-packed lump of dirt along inside of the tire, between tread and fabric, making a place for more dirt to enter. Finally such a large portion of the tread will be loosened as to break away. Then the tire is due for throwing away, or retreading, as the case may be.

**160A. How can this be stopped or remedied?** As soon as such a lump or blister is

stiffeners were made from old strap iron and screwed on. The upper end of the forward post was grooved to take the circular torque tube of about 2 inches diameter, while the two rear ends were slotted down on a diagonal to take the truss rods under the axle. These came down at such a sharp angle as to necessitate a very deep cut on the insides, but this ran out to a fairly shallow one at the outside. The balance of the upper ends was rounded to take the rear axle contour.

By doing these little things, the stand was made so as to take and hold the entire rear construction without clamps or bolts of any kind. Thus the slot for the truss rod prevented the back end from moving in any direction but vertically, while at the same time serving to hold the front end from moving sideways through the rigidity of the whole structure. The rounded upper surfaces served also to hold the surfaces resting on them more firmly. The castors made moving around easy, as before.

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**GARAGE EQUIPMENT.** In general, the new car owner, with a garage, is advised to construct from time to time such equipment and apparatus of this kind as his time, means, and ability will allow; it saves much time and money later, besides expediting work at times when a few moments are worth a great deal. Above all, it makes the man more interested in working on the car and in taking better care of it. Indirectly, it prolongs the life of the machine and gives its owner better value for his money, in that by facilitating repair work when it is needed the car runs better all the time and lasts longer at less expense.

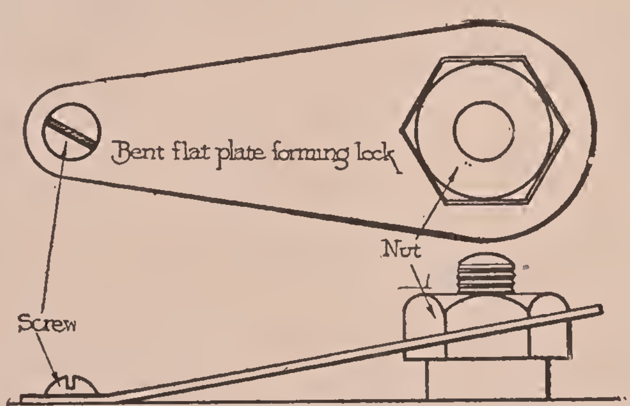

Fig. 59—Simple but efficient nut lock, made from a flat piece of steel, showing how this is fastened down.

Motor car drivers, when beginning to drive and take care of a car, generally assume that all nuts and bolts are tight and remain so, until a loose *battery terminal* or the loss of some valuable and much-needed part proves their error. Then they begin to do what they should have done from the beginning, namely, inspect all visible nuts and bolts before all long trips, the same as all lubrication points are gone over previous to the trip, some of them before the car is taken out of the garage *each day*. This is very necessary, for many of the fastenings come at places where they are subject to continuous shaking, in addition to the big shocks and jolts. The former will loosen and shake off any nut unless it be pinned or held by a lock, or else be so firmly screwed up that the shakings cannot start it.

A simple *nut lock* is the use of a second nut over the first one, but this does not prevent the two from locking together and screwing off as one. A better plan, where the shaft is not drilled for a cotter pin or the nut cut to receive the same and when this cannot be done, is to make nut locks. Next to the cotter pin through a drilled hole and lying in a cut on the outer face of the nut, the simplest form is that shown at Fig. 59. This is simply a *flat piece* of *spring steel,* with a

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noticed, the dirt should be cleaned out of it, first by poking it out of the hole, and then by washing out with gasoline. When this has been done, the inside opening should be filled up with a plastic rubber or rubber solution. In addition, the surface hole should be plugged very carefully and very thoroughly, so that the same old process of filling can not start again.

**161A. Suppose the blister gets large before it is noticed, and then the hole by way of which it started is so small that the material can not be removed in that way?** Then the side of the blister must be cut open. Usually the blister will be close to the edge of the tread and hanging over one side. In that case make the cut as far down the side of the blister as possible. Also, make the smallest possible cut which will allow of removing al the material and cleaning out the inside.

**162A. Should an amateur attempt to fix breaks or wear in the fabric?** No, this part of the tire is so important that only an expert tire man should be put on it.

**163A. What causes ordinary inside fabric breaks?** Contact with a stone, so that generally, a surface bruise and the inner fabric break which goes with it and was caused at the same time, are spoken of as a stone bruise.

**164A. How can this break be explained?** The fabric is strained just as in breaking a

hole cut in one end to fit the nut, and a much smaller one at the other end for a holding screw. When the flat plate has been cut to length and size (it need not be finished up as nicely as the sketch shows), a slight bend near the attaching end will give the upturn which keeps it in the center of the nut and thus prevents the latter from unscrewing so long as the plate is in place. The hole for the nut may be cut out with a cold chisel and is a very simple job on the thin stock used for this.

When this is used and it becomes necessary to take the nut off, the plate is pulled upward so that its lower edge clears the top of the nut, this being accomplished by slipping a screw driver or other tool under the end away from the nut. As this holds it up, the wrench may be slipped under it and the nut freed. After the nut has been taken off, it is well to spring the plate down again as far as possible in order to keep it springy.

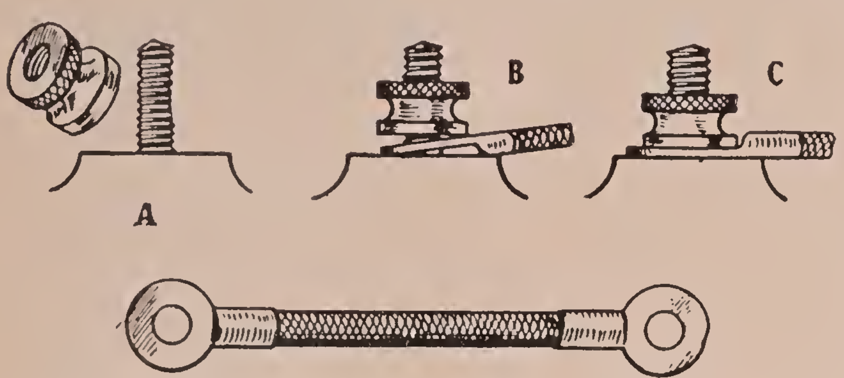

Fig. 60.—The proper and improper method of screwing on battery terminals so that they will stay on and give good contact.

Attention is called also to Fig. 60, which shows how battery terminals may be put on wrong so as to work off very readily. *A* shows the threaded portion and the nut, while the terminal is seen below. This has a flat portion, where the nut is supposed to go over it, and a raised or rounder part where the cable enters it and and makes an electrical connection. By turning the latter wrong side up, as seen at *B,* and then putting the nut on over this, a condition is produced in which the nut is not down tight, so that it will loosen and shake off very readily, in addition to which a very poor electrical connection is made and but a small amount of current will pass.

At *C* the proper method of connecting the two is shown, this indicating how closely the nut fits down to the flat end of the terminal and the latter onto the flat surface of the battery. In this position, the nut may be screwed down so tight that it will not shake or jar loose by using sufficient force, in addition to which a fine *electrical connection* is made all around the surfaces in contact and the maximum amount of *current* may flow.

Another thought in this matter of fastening nuts and bolts is this: Wherever a connecting of rod ends is made so that a pair of members, both horizontal, come together and are joined by means of a pin with a head for one side and a nut for the other, always put the head on *top* and the nut on the bottom. In this case, even if the nut works off, the pin will stay in place due to its own weight and the parts will work almost as well as if the nut were in place. If the nut is put on top, on the other hand, so soon as it shakes loose and the weight of the pin and head are both helping it to shake loose all the time, then the pin has nothing to hold it in place and will drop out. In this way both nut and bolt will be lost and the rod ends will pull apart and cannot be used. If connected with the nut at the bottom, and this shakes loose and the nut is lost, the rods will continue to work.

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piece of wood across the knee. The outer fibers give way and actually break, while the inner ones simply bend and are not severed. In this case the inner layer of fabric corresponds to the outer fibre of the wood, since it is farthest away from the stone over which the whole tire is bent. Consequently it gives way just as the wood does, while the surface of the tire, just the same as the surface of the wood next to the knee, sows no sign of failure even though it has been bent badly.

**165A. How do professional tire repair men repair breaks in the fabric?** It depends on the nature, size and extent of the break. If it goes through the inner layer only, the broken part is cut away carefully and enough more to give a square or rectangular hole sufficiently large to extent beyond the part of the fabric which was strained by the stone bruise. Then a new piece of fabric is cemented into this carefully prepared hole. In addition, the repairman probably will cement in an inner liner around the surface or in the hole and patch where small, say for a distance of 5 or 6 inches beyond either end of it.

**166A. Is a large and severe stone bruise handled differently?** Not essentially. The broken fabric is cut away, making an unusually large hole in the first or inside layer, one not quite as large in the next one, and a smaller one in the next. In this way the hole is stepped down, so that the extreme in-

**NO WRENCHES.** It very often happens that the driver has but a few wrenches with him, and all these are of the *non-adjustable* type. Under these circumstances, a nut is sure to loosen which is too small for the nearest sized wrench to grip tightly enough for turning it up home. This defect may be remedied by using a flat strip of metal between the flat side of the nut and the jaws of the wrench, as shown in Fig. 61. Here a considerable difference is shown, but the writer has known drivers to turn up very big nuts, twice the size of this, with one fairly big wrench, using another fairly small one as the filler or flat strip; or, in some cases, using another nut. So long as some kind of a wrench is handy, the driver can make out, even if it does not fit the nut in question.

A harder problem than this is to tighten or loosen a big nut when all the wrenches are small so that none of them can be used. In this case, the hammer is used, tapping a corner in the direction in which the nut must be turned. One who has never tried this method would be surprised at the ease with which a nut may be taken off or put on in this manner when the process is followed carefully so as not to waste any blows, and to drive only in the one direction. When the nut cannot be reached directly with the hammer, a *cold chisel* or center punch may be used to rest against the faces of it, as they are presented, while the hammer is operated against the chisel or punch. With the former tool, however, care must be used not to chip off the corners, as then the process cannot be continued nor can the nut be screwed on or off without a Stilson or pipe wrench.

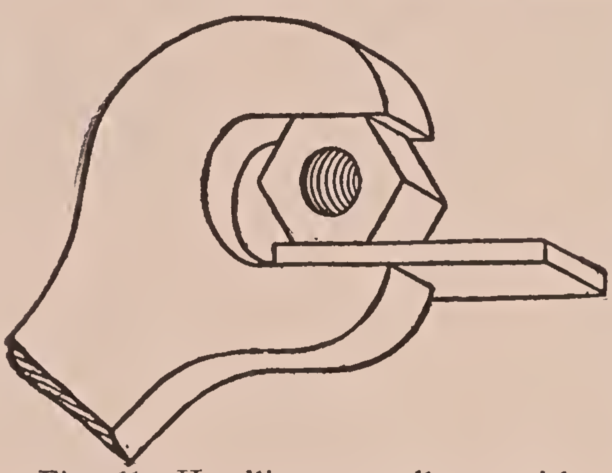

Fig. 61—Handling a small nut with a big wrench is a simple matter when you know how.

Under the separate chapter headings to follow, appropriate repair work dealing with the parts discussed, will be presented. Thus, under-engine parts, as valves and valve parts, pistons, rings, wrist pins, connecting rods, the troubles incident to the operation of these parts will be discussed freely and in detail. In general, it may be said that any part of the car may be put in operating condition by any driver, with a knowledge of the principles upon which it acts, a clear conception of the application of these and a little mechanical skill.

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ner one covers just the size of the hole or weak spot in the fabric. Then, these various layers are carefully patched, one at a time, and allowed to dry so that each is a perfect job. Finally, when the last or inner layer of fabric has been cemented in, the whole is placed in a vulcanizer and cured, the same as the smaller one, but more thoroughly. Moreover, in the small repair it is optional, while with the big one it is a necessary part of the work. When this is finished and the repair has been united with the balance of the tire, the repair man may or may not put in a complete or sectional liner according to his judgment of the need for it.

**167A. Supposing the surface is badly cut by the stone?** The proceeding is just the same, except that the final application includes rubber to fill out the tread, which is not applied when all the damage is inside, of course.

# CHAPTER V.

# Ignition and Carburetion.

**IGNITION** gives the novice driver the greatest amount of trouble, outside of learning to drive and make the more simple repairs, as just explained. A possible reason for this lies in the ordinary conception of electricity as something weird and wonderful but not understandable. Far from this being the actual case, electrical actions and reactions, at least in so far as the ordinary motor car engine's ignition system is concerned, are susceptible to the most simple explanations.

In general, motor car ignition is of two kinds, named according to the source of current: As battery ignition, when the current is furnished by a battery, and magneto ignition when a rotating current generator or magneto furnishes the supply. Under the first named, there are two kinds of battery in common use: The dry and the wet, so called because the active material or electrolyte is a powder in one case and consequently "dry," and a liquid in the other and as a result "wet." Under the second head, also, there are two widely different forms of generator, called the low-tension and the high-tension magnetos, according as the current produced is of a low or a high strength or potential. As the different forms of battery are handled separately, and in a different manner, and as the differing magnetos call for varying accessories, all will be described in detail.

**DRY BATTERIES** are the most simple form of current generator known, the most easily handled, and, to a certain extent, the most easily understood. Due to their general simple appearance and construction, as well as to the current produced which may be sustained by anyone for any length of time without injury, this form of current generator is widely used—in fact, is too carelessly handled in the majority of cases. It consists of a metal casing or can, preferably of zinc, which forms one of the two electrodes, and consequently carries at its upper end one of the terminals to which the wires are attached. It may be mentioned in passing that this is the negative pole of the battery. Within this can there is a lining of absorbent paper, usually thick blotting paper, which previously has been well soaked in a solution of sal ammoniac and zinc chloride. This soaking is highly important and has a big bearing upon the action of the battery. The center of the battery is formed by a round stick of carbon, with a terminal at its upper end, this forming the positive pole of the battery. Around the carbon and filling the whole space inside of the paper-lined zinc can is placed the depolarizer, which consists of manganese dioxide and carbon

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How to Remedy the Most Common Automobile Troubles

**171. How should dry battery terminals be put on?** Unless the end of the wire is laid down flat on the top of the battery, the nut will not screw down tightly, and a good electrical contact will not result.

**172. How should cotter pins be put in place?** If there is an opportunity to put the nut at the top or bottom as the operator chooses, always put it at the bottom, as then, even if the cotter pin shakes out and the nut comes off, the head of the bolt is at the top and it will stay in place.

**173. If the nut is placed at the top, what happens?** If the nut is put on top, this brings the head at the bottom. Then, if the cotter pin shakes out, the weight of the bolt will help to loosen the nut, and as soon as it is loose or lost the bolt will fall out of the hole through its own weight.

**174. Why is the dry battery still used to such a great extent?** Because of its great simplicity and very low cost.

**175. What are its principal faults?** It can be used but once, and has a very short life. Consequently, a heavy demand for current means a very early replacement.

**176. When the engine is ignited by dry batteries solely, and begins to operate intermittently, what is the trouble?** If the engine works correctly for a short time, then misses, then, after standing for a short time, works right again, this is a sign that the battery is getting old and is almost exhausted.

**177. How can dry batteries which have been exhausted be used again?** This cannot be done with any kind of success. In a pinch, the sealing wax which closes the top, may be

dust. This is in the form of a powder, and is packed in fairly tightly, then soaked thoroughly with the sal ammoniac and zinc chloride solution. When this has been done, the upper ends of the paper lining are bent over so as to cover up the whole space, thus forming a top layer of material.

Then on top of this is placed a little sand or sawdust and the space up to the top of the zinc shell filled with a sealing compound, usually pitch, which makes the cell water tight. As the outer material or the zinc can is metal, the round cell is placed usually in a covering of cardboard. This prevents the cells which are set side by side from coming into contact and thus short-circuiting.

The action of the materials within the cell is as follows: Just as soon as the materials are all placed together, the current of electricity begins to flow from the zinc to the carbon within the cell, and when an outside connection is made from the carbon to the zinc through this connection. In this way, a complete circuit is made, from zinc to carbon inside the cell and back from carbon to zinc through the connecting wires outside the cell. The actual electric current is generated by the chemical action between the zinc and the liquid in the electrolyte, this attacking the zinc and combining with it to form a different material which is not chemically active. For this reason, the length of life of the dry cell is determined by the amount of material present, the varius forms being proportioned so as to have them give out at the same time.

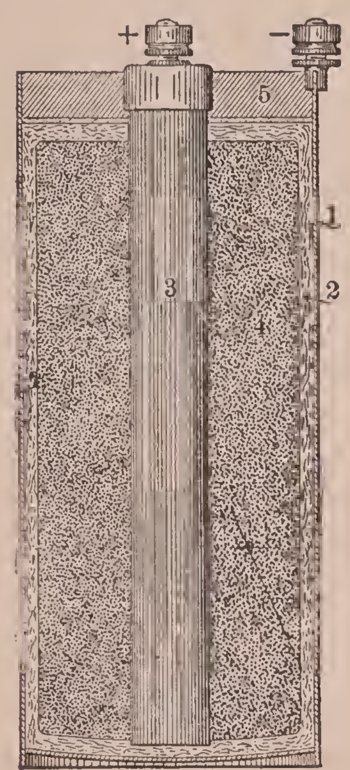

Fig. 62. — Sketch showing how the ordinary dry cell is constructed.

While the chemical action is going on between the active materials and the liquid electrolyte, hydrogen gas is formed and collects at the carbon pole. This electromotive force, in addition to which bubbles form which prevent a good contact with the carbon being made. The whole action is called polarization, and the process of preventing it is called depolarization, and the material used for this purpose, a depolarizer. The manganese dioxide used in the cell's interior is such a depolarizer.

It gives up oxygen, which combines with the hydrogen gas to form water, which remains in the bottom of the cell. In the course of time, however, the supply of electrolyte becomes less and less, until finally no current is given off. In the ordinary cell, a small amount of additional current may be obtained from cells which have been exhausted apparently by making an opening through the sealing compound and the top of the cell, and adding sal ammoniac solution. After this has been done, and the cells have weakened, nothing can be done further, and they must be thrown away. If such an exhausted cell be examined, it will be noted that the zinc shell has been eaten away so that it is as thin as a very sheet of paper, practically but a few thousandths of an inch thick.

The electromotive force of the usual small-sized cell (2½ inches in diameter by 6 inches long) is about 1½ volts on open circuit when new and in good condition. As to current, it will give from 15 to 20 amperes on the average and 25 to

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punctured and water, strong vinegar or other liquids introduced, which will revive the battery for a short time. These are makeshifts, however, and the best plan, even when trying them to get all possible out of the batteries, is to buy new ones.

**178. Is there any other way in which dry batteries may be used again?** If put away on a dry shelf, they will recuperate sometimes, to such an extent as to furnish current for a considerable length of time. Some motorists use dry cells about half their natural life, then put them on the shelf to recuperate, replacing them with new ones. After a while, the old ones are put back in use, the same as if they were new. In this way, it is claimed that from one-half to two-thirds additional life may be obtained.

**179. In a motorboat, what is the most common battery trouble?** The batteries get wet. Water soaks through and short-circuits the battery on itself, rendering it useless.

**180. What is the remedy for this?** Keep motorboat batteries in a waterproof box.

**181. If the batteries are new and the motor will not start?** Doubtless the spark plugs are dirty. This is a common occurrence, the carbon accumulating across the spark plugs' points, so that the current "shorts" across at that point and does not produce a spark. Consequently, the charge is not ignited.

**182. How can this be prevented?** By cleaning the spark plugs' points frequently and by cutting down on the amount of oil used.

28 amperes as a maximum, when the circuit is closed for the first time. In general, the lower reading cells are better, for they will last longer. Where the readings vary widely, it is best to pick out a set which is very close together, as the use of widely varying ones avails nothing, since the additional amperage of the higher ones is used in building up the lower ones to a slightly higher output than had been the case previously. Moreover, a cell which is constructed to give a high initial output is so made that this cannot be continued for any length of time, the result being that a cell which measures up very high at first may be depended upon to last a comparatively short length of time as compared with normal reading cells.

In ordinary ignition work, the pressure required is 6 volts. As has been stated previously, the dry cell gives but 1½ volts, so that a single cell is not

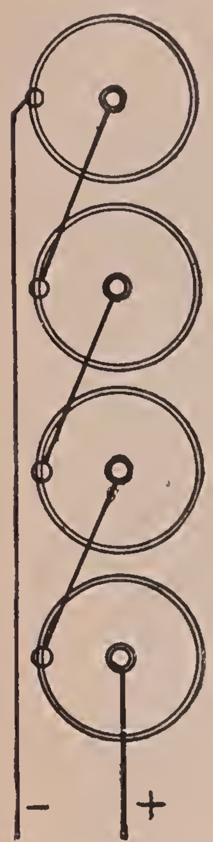


Fig. 63A. — Series wiring of dry cells, which gives high voltage.

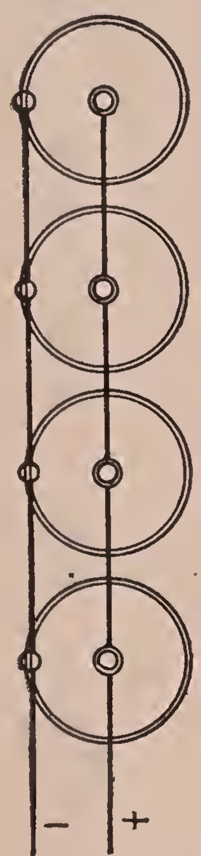


Fig. 63B.—Parallel method of wiring, which produces greater amperage.

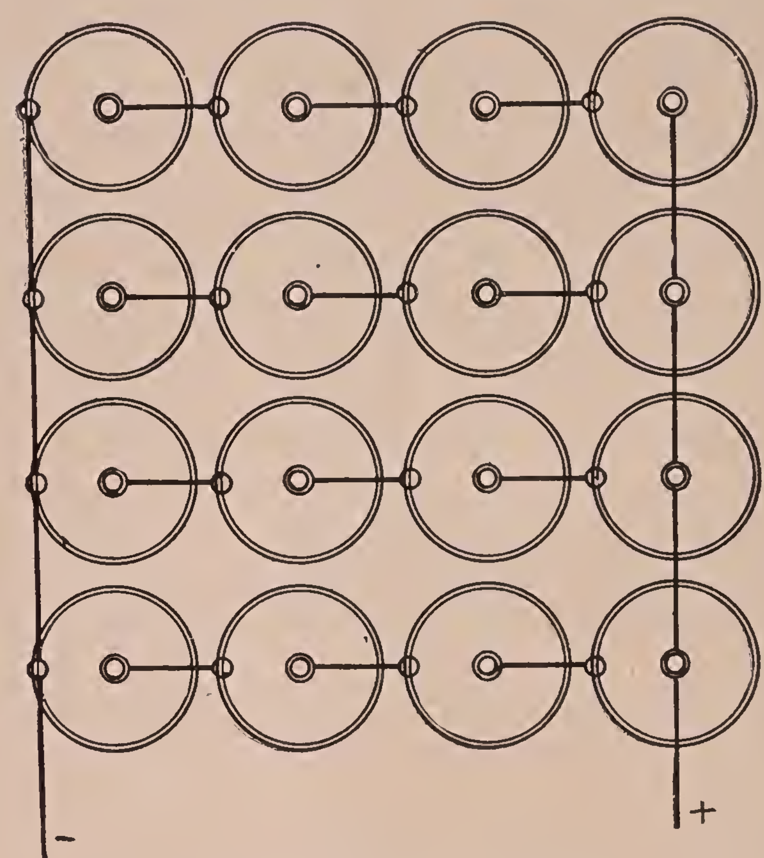


Fig. 63C.—Multiple-Series Wiing; Gives More Voltage and More Amperage.

enough. If the carbon terminal of one dry cell be connected to the zinc of another, the carbon of the second to the zinc of a third, and so on, and the zinc of the first with the carbon of the last used as the two terminals of the group, then these cells are said to be connected up or wired in series. This is shown in Fig. 61. When this is done, the current flowing through the external circuit remains as before, but the pressure is increased, in almost the ratio of the number of cells added to the original one—that is, four cells, four times the pressure or voltage. This is not quite true, for the internal resistence increases more rapidly when cells are connected up in this manner than does the electromotive force, but for practical purposes it may be taken as stated.

Then a series connection gives as much voltage as the sum of the voltages of

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**183. How should the spark plugs be cleaned?** Clean with gasoline and a rag. Or run a very thin file between the points. Or use emery paper or cloth in the same manner.

**184. How should the oil supply be cut down?** After the newness of the motor and its initial stiff have worn off, the careful driver should begin to cut down on the oil flow, both for the sake of economy and to guard against ignition troubles as just described. On some cars, the oil pump of the plunger type may have its stroke shortened or lengthened. The shorter the stroke, the less oil will be pumped and conversely the longer the stroke, the more oil delivered. In others, the size of the orifice may be varied, somewhat in the manner of a throttle. In still others, of the splash type, the splash pans are movable. When moved closer to the conecting rods, less oil may be used. And in various other ways practically all oil-supply systems may be varied.

**185. What is the disadvantage of parallel winding?** It gives a low voltage, so that the ordinary number of cells will not work with the average coil, wound for 6 volts.

**186. What is the disadvantage of series winding?** It does not give a very high amperage or quantity of output, hence the life is short. In this method, however, a high voltage may be obtained, so that it becomes necessary to use it.

**187. How does the multiple-series combine the advantages of both?** The cells are first joined in equal sets, and each of these wired

the individual cells. Thus, four cells, each of which measured 1½ volts, would produce 6 volts when connected in series. So, too, would 5, each of which gave 1.2 volts, or 6, each of which gave but 1 volt.

If, instead of the connections mentioned above, the carbons of all cells be connected and the end of this string of wires used as the positive of the set, and the zincs all connected together and the end one used as the negative terminal for the set, a different result is brought about. This is called a parallel connection and produces the voltage of a single cell (1.25 to 1.5), but a relatively higher amperage, according to the number used. The statement has been made that the resulting amperage is the product of that from one cell times the number of cells, as, for example, six cells, each giving 22 amperes at 1.5 volts when connected in parallel, would give 132 amperes at 1.5 volts. But such a statement is a rough-and-ready rule only, and not the actual output of the batteries. In practice, the actual amount obtained would be somewhere around 120 or less, according to the strength of the cells composing the group. This method of wiring is not used much, for the higher voltage is needed more than the increased amperage in ignition.

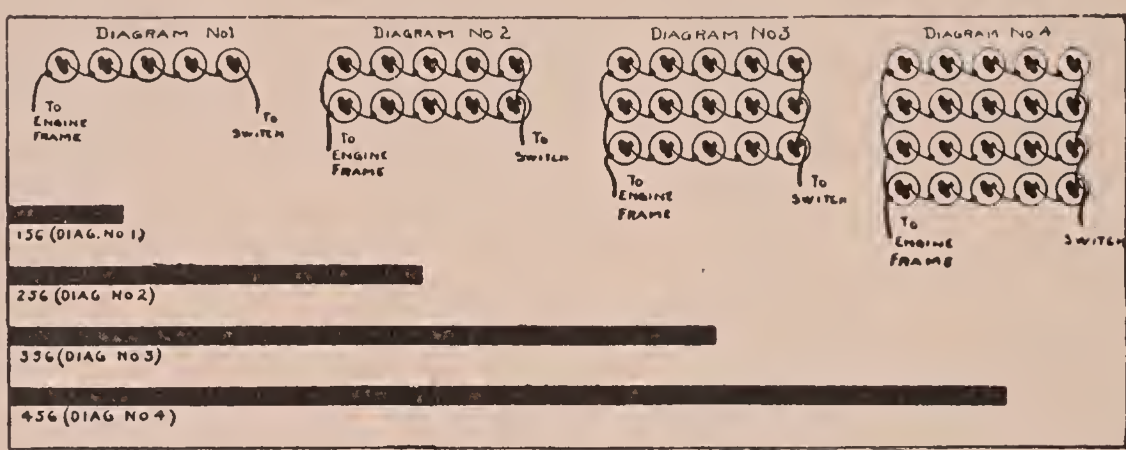


Fig. 64—Sketch showing successive methods of wiring cells, which bring out advantages of multiple-series.

There is a third method of wiring the cells which is supposed to give all the advantages of both the others, with none of their disadvantages, except that it requires a larger number of cells, so that the first cost is greater. This is called series multiple, or multiple-series wiring, and the connections are made as follows: The cells are divided into sets of an even number as, say, four, and each one of these is wired up in parallel. Then all the sets have their terminals connected in series—that is, each set, wired in parallel, is treated as a single battery and wired up with the others in series.

The parallel wiring of the individual cells comprising the sets gives each set the high amperage, slightly less than the amperage of each cell times the number of cells. The series wiring of the sets gives the entire group the high voltage, about equal to the voltage of each set times the number of sets. Thus, suppose a group of 16 cells, each giving 20 amperes at 1.5 volts; these wired up in sets of four, and four of these sets wired in series to complete the group, would give in round figures 80 amperes at 6 volts. Actually the amperage would not be above 70 unless the cells used tested up to 24 or 25 amperes each.

The advantage of this method of connection, and which is said to more than offset the cost of so many dry cells and their terminals and connections, lies in the long life of the group. Thus the life of a large group of cells, connected up

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in series, the number of cells being so proportioned to their individual voltages and the voltages required as to give that figure (usually 6 volts). Then these sets are wired in parallel, giving to the entire group a high amperage output at the voltage prescribed by the coil.

**188. How does this output compare with the same number of cells wired in either of the other ways?** It is said to give more than twice the current output of the same number of cells wired in series, and from that figure on up.

**189. What effect does a single low cell have on a group of them?** It will pull down all the rest, for current will flow from them to it to build it up to their strength.

**190. How does a high cell behave?** In a group, a single cell with a very high amperage will give current to all the others, until the whole group are equal.

**191. In general, what precautions should be observed in picking out dry cells?** Take those which are neither high nor low, and select those which are most nearly equal. It is possible to get cells which test as high as 30 amperes, but these should be mistrusted every time. Others run as low as 20; these are likely to have stood on the shelves too long, and to have lost considerable strength, and to have deteriorated internally. Pick out a set of cells, all of which test from 24 to 25 amperes, or all 25, or all 26, and you will get good results and long life.

in this manner (multiple-series), is said to be much greater than the same number of cells used in single sets, one after the other. A company which advocates this method of connecting dry cells made a long and exhaustive test of the same, and gave out the following figures:

TABLE III.—RELATIVE LIFE OF DRY CELLS.

| Arrangement of Cells. | Hours Service. | Estimated Miles Service. | Relative Value. |
|---|---|---|---|
| 1 set of 5 in series.................... | 20 | 400 | 1.0 |
| 2 sets of 5 in multiple series............ | 70 | 1,400 | 3.5 |
| 3 sets of 5 in multiple series............ | 120 | 2,400 | 6.0 |
| 4 sets of 5 in multiple series............ | 170 | 3,400 | 8.5 |

This is to say, if a set of 5 cells, wired up in series, had been used until exhausted and then replaced by another set of 5 connected in the same manner, 4 such sets would have yielded but 80 hours' service, the equal of 1,600 miles' running. This same number of cells, 20 in 4 sets of 5 each, wired in multiple-series, actually gave 170 hours' service, equal to 3,400 miles' running. Here it is shown that the same number of batteries produced more than twice as much service by a different method of wiring and the use of a larger number at one time.

Taking up the price, it was estimated in the test above that the cost (for batteries only) of running 100 miles in each of the four instances was 25 cents for the single set, wired in series, 13 cents for the two sets wired multiple-series, 11 cents for the three sets in multiple, and but 8 cents for four sets in multiple.

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**WET BATTERIES,** also called storage, and by the English, accumulators, have, as the name would indicate, an all-liquid electrolyte. A peculiarity of this form is that the active material forming a part of one electrode is broken down by the erosive action of the liquid electrolyte, and is carried by it to the other electrode and there deposited. When all of this material has been transposed in this manner, the battery is exhausted and will give forth no more current. If, then, a current be passed through it, this material will be carried back to its original position, when the battery is again ready to produce current and in a quantity entirely dependent upon the character and quantity of current passed through it. If this is thorough, the quantity of current will be almost equal to that produced originally—that is, with proper care in charging and discharging, a storage battery may be made to give forth practically the same amount of current for many, many cycles of discharge and charge. Of course, there is a small loss of active material on each charge and discharge, but this is very slight.

When used for ignition work continuously, a storage battery will give about 3 or 4 months' service before requiring charging. When used for the starting current (ignition) only, such a battery may go a full year without necessitating recharging. For lighting purposes, special batteries are constructed now, these giving a very small amount of current for a very long time.

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**192. If nearly new dry batteries show no current?** The switch must have been left on, so that they exhausted themselves during the night or intervening time, or else some metal object must have been left lying across the terminals of the set in such a way as to short circuit them. In the latter case, they would be exhausted in a very short time, a matter of less than 20 minutes.

**193. Nearly new dry batteries show no current when connected up—that is, they show a little but not what they should.** One connection may be reversed, so that current is flowing in the wrong manner in two cells of the set. This will lower the output almost to zero.

**194. New dry batteries test up 25 amperes each. When wired up in a set, in series, they do not show even this amount. What is the trouble?** Probably a loose terminal, or a worn or faulty connection, as a well-selected set of cells, of 25 amperes each, should show about this figure when connected up in a set, wired in series.

**195. There is a buzz inside the coil, other than the buzz of the contact breaker.** Probably a short circuit in the coil windings or connections.

**196. If the former, what can be done?** The coil can be dried out close to a fire or in any other warm place. Aside from this and inspecting it for loose pieces of metal which might have caused the trouble, the amateur can do little except replace it with a new one.

**197. How can trouble of this kind be proven definitely?** Aside from the buzz mentioned, which comes from within the coil, the engine will be noted to run poorly on it. This can be tested by borrowing a coil and putting in

Storage or wet batteries are of two kinds: The ordinary, simple cell, such as is used for electric bells in houses, and the usual ignition battery for motor car work, which contains three cells (ordinarily). The former is illustrated at *A*, Fig. 65, and consists of two sheets of lead, rolled to form spirals, and separated top and bottom by insulating bands of hard rubber or fiber. The electrolyte is dilute sulphuric acid. After this has been charged by passing a current through it, the nature of the lead plates will have been changed so that they are different substances, and a chemical action will be set up which will produce the desired current.

Lead is also the material commonly used for batteries such as that shown at *B*, Fig. 65. While this appears like one, it really is three cells, and contains three positive and three negative plates. The plates are made of sheet lead, with perforations or pockets, which are filled with a paste made from oxide of lead. The plate with its pockets filled is then treated chemically so that the paste is set firmly, while its chemical composition is changed at the same time. In its final form, the positive plate is filled with dioxide of lead, both this and the plate having a brown or chocolate color. The plate forming the negative electrode is so treated as to remove the oxygen from the paste material, leaving metallic lead in a spongy form with a characteristic lead color.

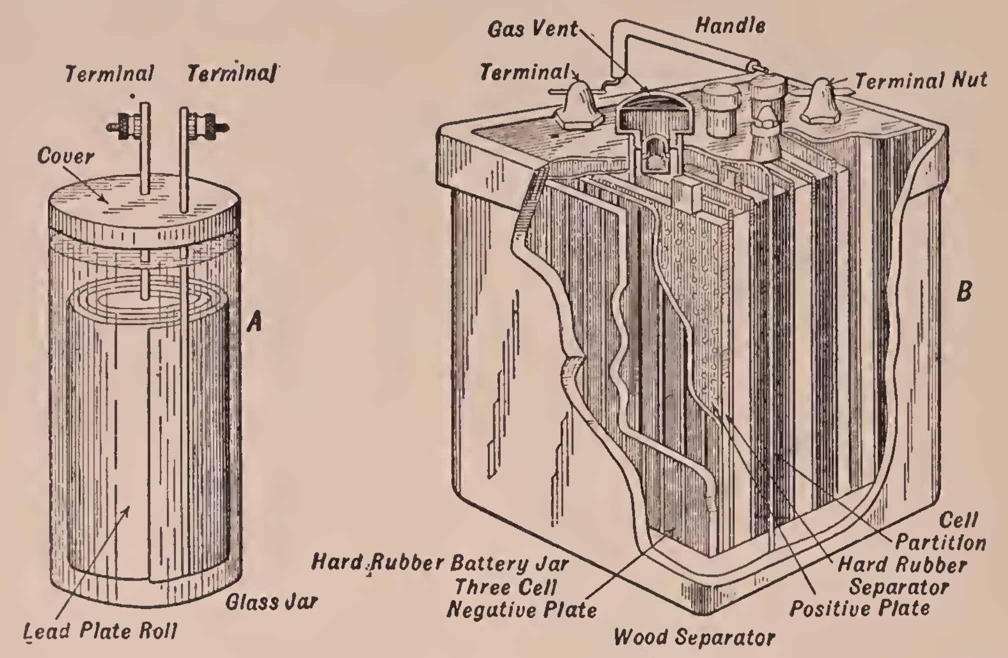


Fig. 65—Wet or storage cell construction. At left, simple primary cell. At right, three-part or 6-volt battery.

With this form of cell, the electrolyte is dilute sulphuric acid, which must cover the plates completely. When charged and ready to begin generating current, such a cell will deliver about 2.2 volts on open circuit. The amperage will vary with the number of cells united to form the battery; but, speaking generally, wet or storage batteries are rated by ampere-hours. An ampere flowing for one hour, or 2 amperes for one-half hour, or ½ ampere for two hours each constitutes an ampere-hour.

In a battery of this kind, the specific gravity of the electrolyte must be kept up to 1.205, or as close to 1.2 as is practical. If it falls below this, more acid of the right content should be added when the level is low. This measurement is made with an instrument called the hydrometer, an instrument resembling a thermometer except that it is much larger and longer, and has a very large bulb at its lower end which is dipped in the liquid.

For ignition work, the three- and four-cell forms are used mainly. The general descriptions of these are given in the table below, which while it describes the product of one manufacturer, covers practically all of the makes as to size and output.

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the place of the regular one. By interchanging the two and noting how the engine runs, the defective one can be shown up very effectively.

**198. What good does drying or heating the coil do?** If the internal trouble is due to water which has gotten into the interior by accident, heating or drying will drive this out. If this was the only thing causing the trouble, and the coil is dried enough to drive all of the moisture out, it will be as good as new after the treatment. In such heating, however, care should be taken not to heat it too much, as it is possible to melt the insulation of the wires, or between the two sets of wiring, thus causing more trouble than before, and practically ruining the coil.

**199. There is a tiny or intermittent buzz at the contact breaker, quite different from the correct noise made when breaking the circuit.** This probably represents a pitted coil point. In order to withstand the heat generated when the spark passes from point to point, these are faced with platinum or a platinum-iririum compound. If there is a flaw or weak spot in this, a pit or small hole will develop. Sometimes the entire surface will be covered with these tiny holes. Since the surface is not plane and smooth, a poor spark results from the poor contact which such surfaces make. To remedy the different noise, which indicates a poor spark at the plugs, the points must be filed to a good even surface.

SIZE AND CAPACITY OF IGNITION BATTERIES.

(All these are 9 inches high and 6⅜ inches wide.)

| No. of Cells. | Volts. | Ampere-Hours Capacity. | Inches. | Pounds. |
|---|---|---|---|---|
| 3 | 6 | 40 | 7 7/16 | 25½ |
| 4 | 8 | 40 | 9 5/16 | 34 |
| 3 | 6 | 60 | 9 15/16 | 34¾ |
| 4 | 8 | 60 | 12 9/16 | 47½ |
| 3 | 6 | 80 | 11 13/16 | 46 |
| 4 | 8 | 80 | 15 1/16 | 61 |
| 3 | 6 | 100 | 14 13/16 | 55½ |
| 4 | 8 | 100 | 19 1/16 | 74 |

More recently, 6-120, 8-120, 6-140 and 8-140 batteries have been produced in response to a wide demand, but the dimensions and weights of these are not available.

The chemical changes going on when a storage battery is giving off current are as follows: The dioxide of lead is changed partly to monoxide of lead by the loss of part of its oxygen. The metallic lead also is partly changed to monoxide by the addition of oxygen. The sulphuric acid is reduced by decomposition into sulphur and water, so that the electrolyte becomes weaker and has a lower specific gravity. During the charging process, the above reactions are reversed and the original conditions are restored, with the exception of the sulphuric acid, which must be added to from time to time in order to maintain the most efficient strength and the correct specific gravity.

**THE EDISON BATTERY** differs from the lead cell, just described, in a number of important particulars. First, the active material is iron oxide, which is used with nickel and iron. Second, the electrolyte is a weak alkali instead of a strong acid. Third, the cell is so constructed as to be foolproof throughout, even in the matter of charging or discharging, presence of or lack of electrolyte, and other matters which are vital with the lead form. For these reasons, the Edison battery is being adopted widely, despite a higher first cost.

The pressure of the current generated by either a dry or a storage battery being so low, 6 volts on the average, and never above 10, while a considerable amount of pressure is needed to make the spark jump across the air gap, some means of increasing the pressure is necessary. This is found in the spark coil, which is in effect a transformer, changing a low-tension current into one with a pressure of several thousand volts.

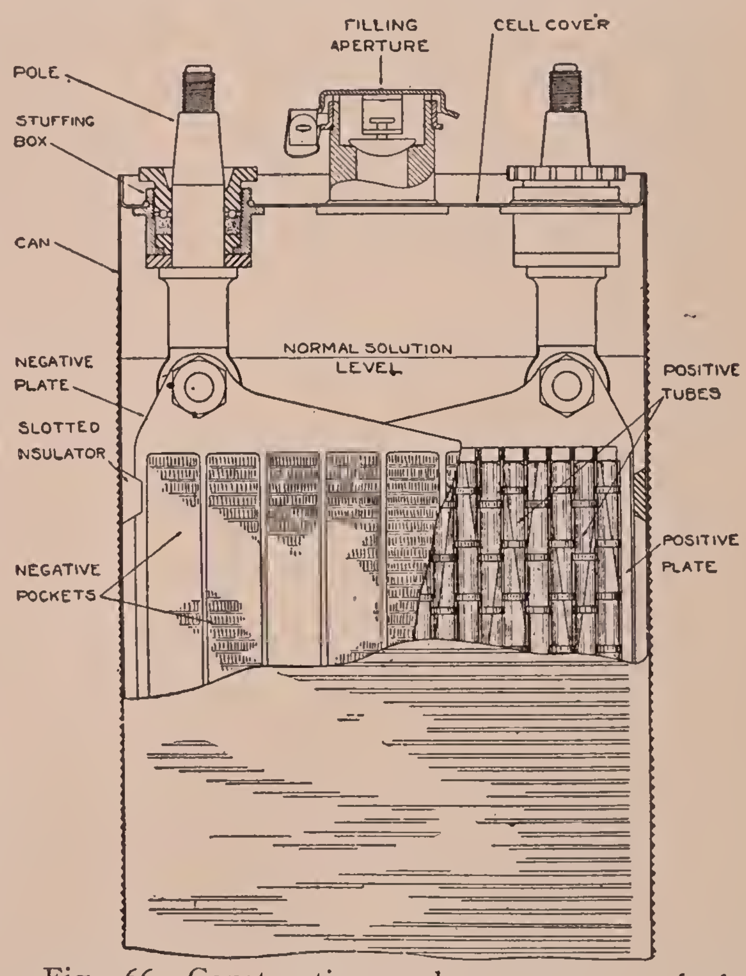


Fig. 66—Construction and components of the Edison battery, which uses no acid and is foolproof.

**200. How is this done best?** By using a very fine, flat jeweler's file, and using extreme care to get the surface exactly parallel with each other, and each one as perfect as possible. In doing this work, file away as little material as possible. If much is filed away, the points will stand but one or two dressings, as not much of it is used on account of its high cost.

**201. Can a tool be made for doing this work more accurately?** Yes, and this represents the best way of doing it. A board should be constructed with a place at the top into which the contact point can be screwed or fitted tightly. Then there should be a place at the bottom into which a fine oilstone or very fine file can be set. Then there should be a means of moving the top so that the contact point passes over the file or oilstone, but in such a way that it cannot possibly meet it except at a perfect right angle. With a device of this kind, it is possible to put in the point, work it over the stone and be sure of getting a perfectly accurate surface.

**202. What causes weak or uneven running on a magneto system?** Dirty contact blades in the contact breaker, or pitting or wear of the blades. In some very few cases it may be caused by the use of inferior material for the contact blades or other parts.

**203. How can these troubles be remedied?** By cleaning or filing down to an even, per-

**A SPARK COIL,** in its simplest form, consists of about 200 to 300 turns of comparatively thick copper (or iron) wire, insulated, and wound on or around a soft iron core piece, with some 1,500 to 2,000 turns of a very thin copper wire wound over the thick, having, however, a form of insulation between the two, in addition to the insulation of the wires themselves.

The first layer of thick wire is called the primary winding, and receives the low tension current from the battery. For this purpose, it usually is made complete in itself, and the two ends are carried out to the outside for battery connections. In Fig. 67, and usually in electrical work, the primary winding of a coil is shown by means of a heavy line. The upper or outer layer of fine wire is called the secondary winding, is represented by a fine line in Fig. 67 and generally, and is carried out with two outside terminals, one for the spark plug, and the other for a ground or other connection.

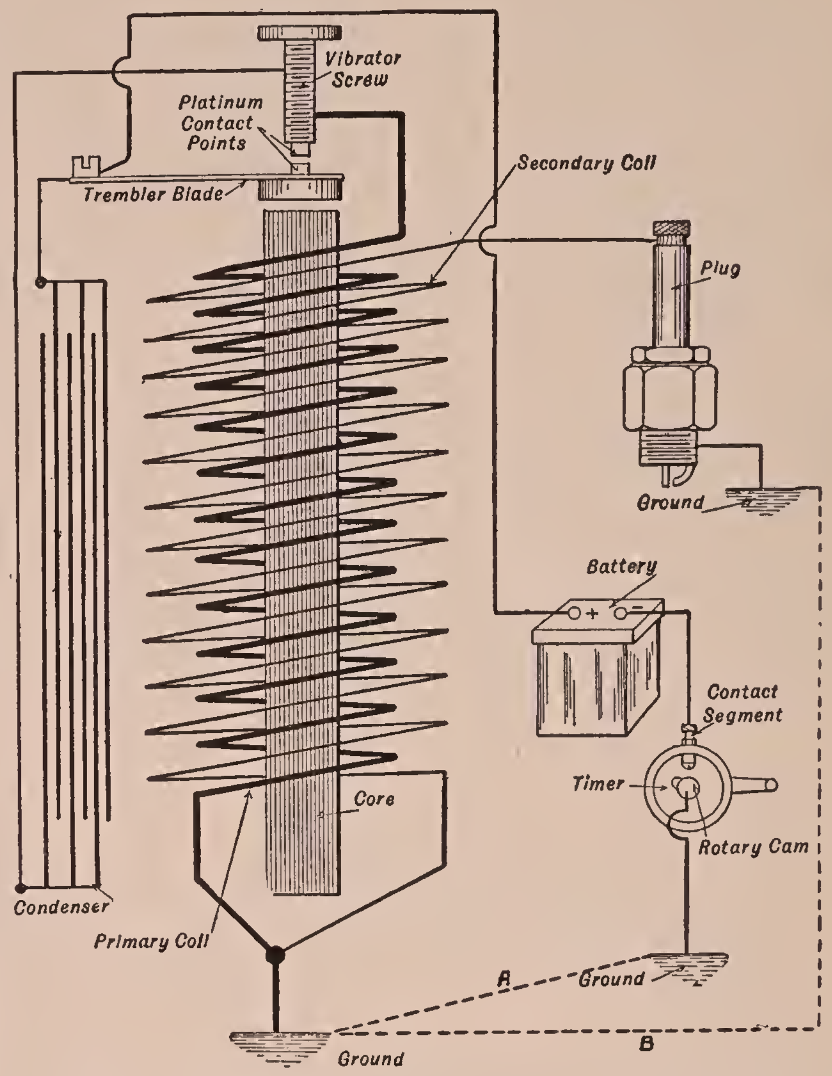


Fig. 67—Components of the coil and other parts of the jump spark system, showing operation.

When a low-tension current is passed through the primary windings and then *suddenly* broken, a current of extremely high tension (upward of several thousand volts) is generated in the secondary windings, sufficient to jump across the air gap at the spark plug which forms the break or gap in the secondary circuit. This spark appears only *after* the primary circuit has been interrupted, and only when it has been interrupted *suddenly,* no spark appearing either at the time of closing or when the primary circuit is opened gradually.

The action within the coil is as follows: The current through the primary winding magnetizes the iron core. As this current ceases, when the primary circuit is broken, the core loses this magnetism very rapidly. This rapid decrease of what is known as magnetic flux induces electromotive force in the secondary, but because of the circuit being open at the spark gap, this induced electromotive force continues to build up pressure in the secondary until it is sufficient to jump the gap, or, in electrical terms, until the difference of potential between the two sides of the spark gap causes a spark to pass across.

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**THE TREMBLER** in a spark coil is nothing but a steel spring, employed to break the primary circuit automatically. It consists, as Fig. 67 shows, of the trembler blade, which is the steel spring, and carries at its lower side a small piece of soft iron or other metal, while on

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fectly flat surface, or replacing with good new parts respectively.

**204. What causes an automobile to smoke?** Imperfect combustion of the fuel, too much lubricant, or a combination of the two.

**205. How can these be detected?** By the color of the smoke which issues from the exhaust pipe. A very dark brown color indicates an excess of lubricant, while a light gray but very noticeable smoke denotes fuel going to waste. Ordinarily the exhaust should be colorless outdoors.

**206. How can the excess of fuel be cut down?** By opening the auxiliary air valve so as to give the carburetor more air, and thus vaporize a greater amount of fuel, instead of letting it go to waste. An alternate method is to screw the needle valve which supplies the vaporizer with fuel down so that not as much will flow through.

**207. Which method is preferable?** It depends upon the nature of the engine and work being done. For hard, heavy or fast driving, it would be better to give the motor more air and let the fuel stand. On the other hand, for ordinary city driving, or similar work over good roads or pavements at moderate speeds, it would be better to cut down on the fuel. This not only saves fuel and thus

the upper surface there is a platinum contact point. Above this there is a fixed member, through which the primary current flows and which carries on its lower side another platinum contact point so as to make an exact contact with the one on the upper side of the movable trembler blade. In actual practice, it is not possible to make all of the springs alike, nor do all ignition systems work best on the same amount of movement, consequently the fixed contact point is made in the form of a fixed bridge with a screw at the center which may be adjusted to suit conditions, its lower end having a platinum tip to match the contact on the trembler.

The action of the trembler is as follows: When the low-tension current from the battery passes through the fixed contact point and the soft iron core, as the latter builds up its magnetism, the free end of the trembler is attracted to the end of the core and away from the fixed arm or contact point on the end of the vibrator screw. When the magnetism reaches its maximum, the two are pulled apart, which breaks the primary circuit and interrupts the flow of current through the primary windings. As soon as this current stops flowing, the core loses its magnetism as explained previously, and the free end of the trembler is no longer held close by it. Consequently, the spring draws it back to its original position, in which its contact point meets that of the fixed trembler screw, closing the primary circuit again. This same operation is repeated over and over again, as long as there is current from the battery. Each time the moving of the trembler arm breaks the primary circuit, a spark is produced at the spark plug, as previously explained in detail.

The trembler spring is made strong enough so that its free end does not touch the end of the core, as it would cling there and stop the operation of the device. Either that or a non-magnetic substance, as rubber, wood or brass, is used to check its movement before it touches the core.

This arrangement gives the automatic action of breaking the circuit frequently and the subsequent closing of the same as soon as the spark shall have been produced. The adjustability of the screw arrangement allows of varying the amount of the trembler movement, which in turn determines the quickness of the break and also the speed or rather interval of time in which it is re-established. The former fixes to some extent the character of the spark, since the quicker the break the better the spark, while the latter is necessitated by the modern high speeds of multi-cylinder engines.

Thus in a four-cylinder motor, turning over at the rate of 1,500 revolutions a minute, there is an explosion every 1/50 of a second. Considering the lag in building up the current, in making the break, and re-establishing the circuit, it would appear that about one-third of this time should be given to each operation, or 1/150 of a second to each. Considering this extremely short interval of time, it is important to have the vibrator screw adjusted so as to give the maximum possible speed of movement. There is a second point to consider in adjusting this member, namely, the economy of current. Thus, the vibrators may be adjusted to take a small or a large amount of current and still give satisfactory service at both positions. The amount of current drawn is usually considered to be but ½ ampere when adjusted correctly. If more than this is used, the adjustment should be changed.

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money, but eliminates the smoking nuisance as well.

**208. What other benefits result from making these changes?** In any case in which the motor is smoking badly there is sure to be much excess carbon in the cylinders, due to an excess of oil or fuel as the case may be. This will settle on cylinder heads, valves, valve caps, spark plugs, or other parts of the interior and cause missing. Ultimately smoking, if long continued, will mean overhauling the engine at an early date.

**209. What is the use of the air valve?** It supplies a method of adding air to the partly vaporized fuel, and a variable one as well, so that the amount taken in may be changed to suit the atmospheric or other conditions.

**210. Does it ever get out of order and cause trouble?** Yes, sometimes through lack of sufficient tension in springs or loose nuts, or other fastening means, the adjustment varies so as to throw out the perfect running of the motor, causes missing and possibly stoppage. The spring holding the air valve on its seat and against the pressure of which the engine suction opens the valve and draws in the air may break. This will hold the valve open all the time, with the result that the motor gets too much air.

**211. How much air is necessary ordinarily?** The best results are obtained when the volume of air is about 7 or 8 times the volume of the gasoline vapor. When the ratio gets below 4 to 1, it is too rich, and will cause

**THE CONDENSER** is another component of the vibrator coil as compared with a non-vibrator form. During the first part of the break in the primary circuit caused by the downward movement of the vibrator spring, the tendency is for the current to keep flowing across this gap and thus burn away the contact points. When a condenser is used and wired in parallel with the system, this excess current flows to the condenser and charges that, this extra amount of current being saved in a sense; for, when the circuit is broken, this current flows back through the primary. On account of the momentum of the discharge current, the condenser becomes charged again, but to a less extent and with a reversed polarity. Then it discharges in the opposite direction, and continues to oscillate from one direction to the other. This produces a series of small sparks at the trembler contacts, which is considered as a single spark and is used by drivers as an indication of the action of the system, according as it is strong or weak, quick or slow.

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**THE TIMER** is the other member necessary in a system of this kind, this being a member which has a rotating metal shaft, driven positively from the engine. In addition, it must carry a moving cam which makes a contact with a metal contact segment set into the inner surface of the timer, the cam being insulated from the timer case at all other points of its revolution. In the sketch, Fig. 67, but one of these is shown, as would be the case for a single-cylinder engine. With a two-cylinder motor, there would have to be two; with a four, four; with a six, six; and so on. The timer is set to turn at one-half the engine speed, consequently the cam makes a full rotation and contacts with all segments in two revolutions of the crankshaft.

When this contact is made, current may flow through the coil from the battery, but not until then, for the timer is a part of the primary circuit, and, as just pointed out, the case is insulated from the shaft, and current can flow only at the contact points. This being made, the current flows, builds up the circuit, attracts the trembler, which moves downward and breaks the circuit, causing the generation of the secondary circuit, which jumps the gap at the spark plug, this being the spark which ignites the compressed gases in the cylinder. When it is desired to run the engine faster, this spark must occur at an earlier point in the stroke, and when the driver wants to turn his motor over still more slowly, it must occur at a later point. For these reasons the casing of the timer is made movable, and is connected to the throttle lever, which the driver moves with his finger. When an advance is desired, the casing of the timer is moved against the direction of rotation—that is, toward the rotating cam—so that it meets the latter at an earlier point than would be the case otherwise.

One thing that usually is puzzling to the amateur, studying out ignition systems, as shown in Fig. 67, for instance, is that neither the primary nor the secondary circuit is completed. This is explained by the fact that the ground forms the missing side. Ordinarily this is not shown as connected, since everyone knows that given two connections from different parts to the same metal bar or piece is the same as connecting the parts together directly. In the diagrams, it is understood that these grounds are connections to metal parts of the frame,

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smoking, previously mentioned. When more air is admitted, the engine will run and act all right up to 15 to 1, beyond which it will not operate. If more than 15 parts of air be admitted to each 1 of gasoline vapor, the motor will not operate.

**212. In what other way can too much air reach the motor?** Through leaky joints in the carburetor connections or inlet pipe, through a pin hole or crack in the inlet pipe, or through a leaking inlet valve. This gives one clue to a sudden stoppage of the motor at a time when it has been running well. Any one of these things may have happened, as for instance some dirt may have held the inlet valve off its seat, so that air leaked in in that way.

**213. What causes the hissing sound in the air valve of a carburetor?** The gases being drawn over the surface of the valve. This cannot be stopped, but sometimes it can be quieted by changing the setting of the valve slightly.

**214. What causes a hissing or popping noise in the carburetor or inlet pipe?** The trouble known as a "blowback." That is, the blowing back past the inlet valve of gases. Sometimes this occurs after the gases in the cylinder have been exploded, so that a flame may spurt out of the air pipe of the carburetor.

**215. What could cause this?** A pitted inlet valve, grit under the valve, a broken valve, defective or broken valve, spring valve, stuck in

which latter forms the closing part of the circuits, the primary in one instance and the secondary in the other. In the figure, these ground connections are indicated by means of dotted lines to make the whole thing more clear, dotted line *A* indicating the connection and flow of current for the primary circuit, and dotted line *B* indicating the same for the secondary circuit.

**SPARK PLUGS** form an important part of the ignition system, and an indispensable one. They consist broadly of a central metal point of electrode which carries at its upper end a terminal for wire connections, an outer metal shell which is screwed into the cylinder, and, as the latter is metal, also makes an electrical connection between the two, and an insulating material which separates the two. From the outer metal shell a second electrode extends down to meet the two, these being set so that an opening of approximately 1/32 inch exists between their tips. This is about the correct sparking distance for batteries and one-half this for magnetos, as more width makes too big an air gap, renders it difficult to get a proper spark and consumes too much current. On the other hand, too small a gap allows the current to flow too easily and the spark produced is not hot enough.

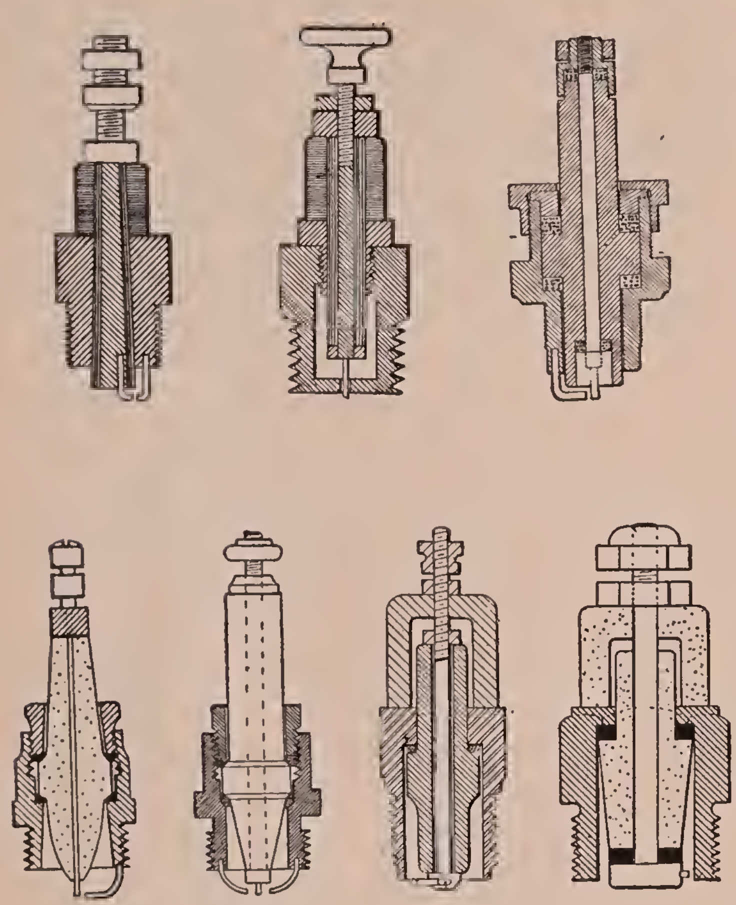

Fig. 68—A group of modern spark plugs indicating the differences in construction.

The tips are fitted with platinum in order to make them last as long as possible, considering the intense heat to which they are subjected. When considerable oil is used in the cylinders, these points may become clogged with carbon sufficiently to form a bridge across the points through which the current may pass continuously. In that case, there will be no spark to explode the charge, and it will be compressed, but the explosion will be missed. This condition is spoken of as missing, and the remedy, in addition to cleaning out the cylinders thoroughly and using less oil, is to take the spark plug out, clean off the points with emery cloth until the metal is so clean it shines, then reset the points to the correct distance apart and replace.

All of the foregoing has been descriptive of the low-tension ignition system, in which the source of current was a dry or wet battery. When a rotary generator produces the current, conditions are changed considerably, even if this be a low-tension generator. When the current from the latter was used, a form of circuit breaker which was driven from the engine so as to be exact had to be used, the nature of this giving this form of ignition its name of make and break. As this has gone out of use now, it will not be described further. The drawing, Fig.

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the open position through gummy stem, bad carburetion in combination with spark retarded, fully retarded ignition at starting time, a back fire when starting due to ignition adanced too far, or faulty timing. Any one of these or any combination of them will bring about the trouble mentioned.

**216. How can these be remedied or prevented?** Practically all of them can be remedied by thorough care and common cleanliness. Thus an inlet valve stem sticking because of gummed oil could have been prevented by using less oil on it, or cleaning with kerosene if it got too much by accident.

**217. When the engine stops, after running along all right for some time, and ignition and carburetion systems seem to be in good condition, while there is fuel in the tank.** There may be water in the gasoline, this got in through not using a strainer in the tank. Chamois is the best thing through which to pass gasoline, as it will take out impurities which a brass gauze strainer will not. Every fuel system should have strainer and filter at the low point. If this were the case, the water would be separated out by it, and consequently would not get to the carburetor.

**218. In what other ways may the engine be stopped, considering only those faults due to the carburetion system?** By a choked supply pipe to the carburetor, caused through

69, however, shows the current generator, its connection by means of a single wire to the bus bar, along the tops of the cylinders, and the further connections from this to the individual igniter contacts. The dotted portions of the latter show the movable lever within the cylinder, at the points of which the spark usually occurs when the break. The shaft along the front of the cylinders with the spiral cams is driven from the motor and controls the breaking action at the four points. The purpose of the spiral cams is to vary the time of the "break" according to the speed of the motor. For this reason, the shaft may be moved longitudinally, in which case the rollers have a different position in the cams and consequently the "break" comes at a different point in the stroke. Their shape and size is so arranged as to give fully as wide a variation from fully advanced to fully retarded, as is the case with any other form of ignition. It will be noted that cylinder No. 4 is in contact, while the other three are not, which is correct. The system shown is that of the Studebaker car, and is no longer used, as stated previously.

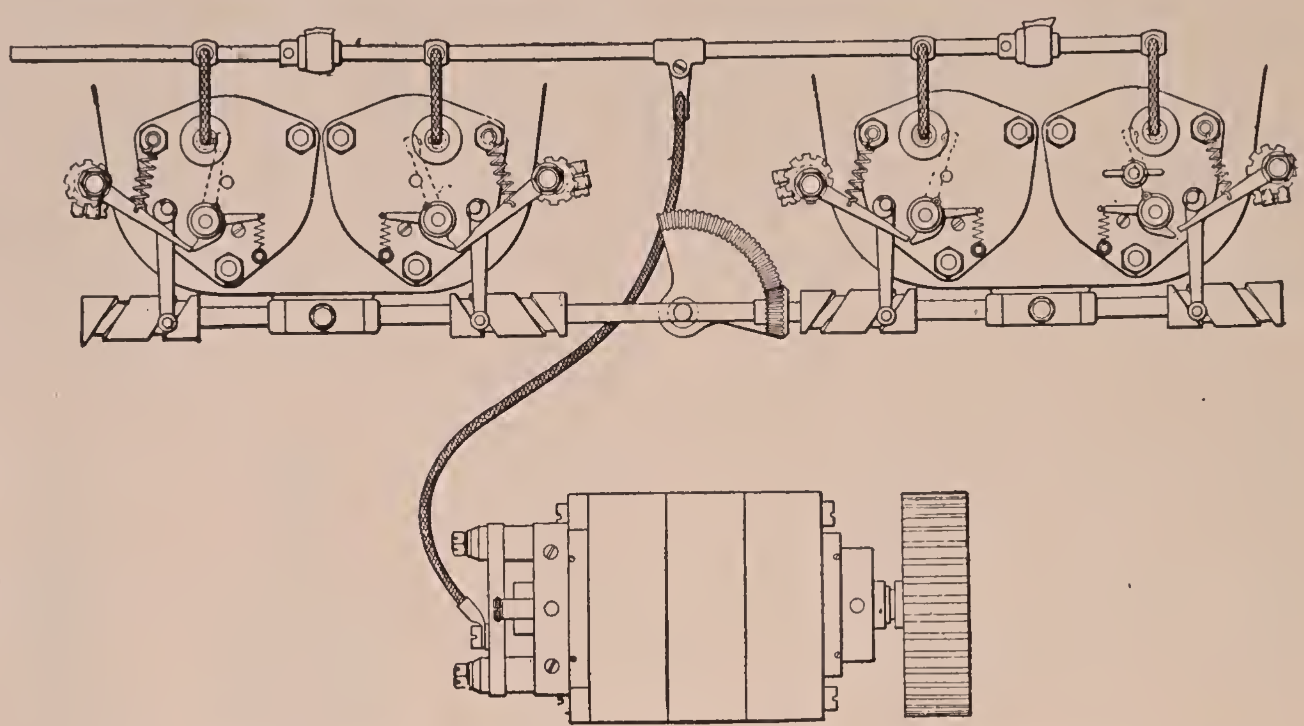

Fig. 69—A low tension system of ignition formerly used on Studebaker cars.

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**LOW-TENSION MAGNETOS,** or current generators, are still used, however, with a coil to step the current up to the required tension or pressure. The reason for their use lies in the simplicity and low first cost of the generator, its small number of parts making it well-nigh impossible to get out of order. In addition, the wiring is very simple, and short circuits caused by water or oil need not be considered to any great extent because of the nature (low tension) of the current.

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**USING THE COIL,** this unit performs for both the battery starting system and the magneto operating system. In the form shown by outline at Fig. 71, and in diagram of wiring at Fig. 70, it will be noted that this member (the coil) is of the non-trembler type with its own condenser. The distributor on the magneto, and driven at half the armature shaft speed, is used as a timer for both systems, while the interrupter of the magneto performs the function of a circuit breaker or trembler for both systems also.

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dropping waste or other foreign matter into the gas tank; by an air lock in the supply pipe, caused by closing the hole in the top of the gas tank filler plug; by a choked jet, a carburetor filter choked, a poor mixture, the gasoline in the tank not reaching the carburetor, no gasoline in the tank, and the oldest and simplest of all, gasoline not turned on.

**219. In climbing a hill, the motor stops for no apparent reason.** It may be nothing more than the change of level caused by the relative positions of the gas tank and the float in the carburetor. The latter may be inclined so much that no gas flows at the nozzle, causing the stoppage, or the whole carburetor may be cut off so that no gas flows to it.

**220. The motor operates nicely, then after passing over a bump in the road stops suddenly.** The float may have been dislodged from its position, the stem bent, and the whole so jammed as to stop the flow of fuel into the float chamber. In that case, the engine would run until the gas in the float chamber had been exhausted, then stop because there was no more fuel admitted.

**221. Is this a common occurrence?** No, but a serious one, for the bent float valve stem is hard to straighten so that it will act perfectly thereafter. Usually a very slight bend will be left in it, and this will be sufficient every now and then, when conditions are favorable, to cause it to stick again, the former stoppage being repeated then.

When the battery is furnishing the current, it flows through the interrupter and switch to the coil, thus forming the primary circuit. The secondary is formed by the coil, the distributor, the spark plugs, through the ground screw of the interrupter to the ground.

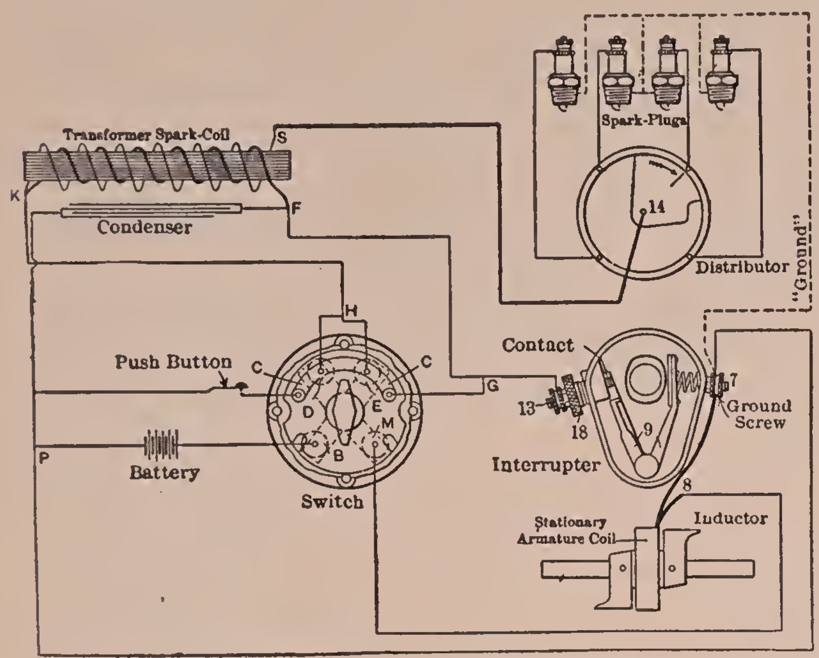


Fig. 70—Simple wiring of low tension magneto indicated in diagram form.

With this same system, as the wiring diagram outlines, when the magneto is furnishing a low-tension current, it flows through the interrupter, switch, and coil as before, these with the ground forming the primary circuit. The secondary is made up as before of the coil, the distributor, the spark plugs, and the ground through the ground screw on the interrupter. The only difference between the two is the source and character of the current from the batteries and a direct current in one case, and from the magneto and an alternating current in the other.

While this has been called a low-tension system, and properly is such—for both current producers bring forth a current of low pressure—still its maker calls it a high-tension system, from the fact that a current of high pressure is produced finally at the spark plugs. This being contrary to the custom of nomenclature, has done much to confuse users of this particular system.

## TRUE HIGH-TENSION MAGNETOS

represent, however, the greater part of the current generators in use to-day. If standard practice and popular approval count for anything, this is the most successful form by far, since it outnumbers all others. Such a system uses no separate coil box, having the coil incorporated in the magneto, as well as the condenser. In this way, the current generated is of the high-tension type, so that the incorporating of a low-tension circuit breaker and a high-tension current distributor in the instrument makes it self-contained and complete. With this modification, however, at the low speeds of hand cranking, varying from 80 r.p.m. down to as low as 40 r.p.m., the current generated by the magneto armature and the consequent spark are so feeble as not to ignite the charge readily.

For this reason, it is customary to fit a battery system to the magneto system in such a way that the incorporated parts of the low-tension circuit breaker, high-tension distributor, and coil are made use of for both. Where the coil is a separate unit from the magneto—that is, not incorporated in the latter but carried in a separate box on the dash or elsewhere—it is used for both systems the same. When this double system—or, as it is called by the majority of makers, dual system, since a number of parts perform dual functions—is used, the battery current is used for starting, and for that purpose only.

**222. After a similar bump, the motor seems to pick up speed and run faster than before, while missing occurs occasionally, and the exhaust begins to show signs of dense smoke?** In this case, the float has jumped off its seat and jammed in such a way that it does not operate, and the gasoline flows right through to the needle, flooding it. The motor is receiving too much fuel, and is wasting the excess.

**223. The carburetor floods, but the float is in its correct position, and the valve is not stuck, nor the stem bent or jammed?** The float, if a cork one, may be watersoaked or rather gasoline soaked, and, if a metal one and hollow, may be punctured. Cork floats are covered with a coating of shellac to protect them, and the impure fuel may have eaten this off, after which the cork will soon become soaked, and consequently heavy. It will not act as it did before, and will let more gasoline pass.

**224. How can this be remedied?** The float can be taken out, dried thoroughly, and then re-shellacked. In a case of this sort, it is advisable to play safe and give the float while it is out of the vaporizer several coats of shellac.

**225. How can the punctured metal float be remedied?** Take it out, heat to drive out all of the fuel left after emptying what will come out in that way, then solder the hole. Difficulty will be encountered in finding this if it be small, but it can be found by heating

As soon as a start has been made, the switch, generally located in the center of the dash or at another equally convenient place, is thrown over to magneto. The latter is used for continuous running. Under these circumstances, the small amount of current taken from the batteries gives them a very long life as compared with their short existence when used continuously for ignition purposes.

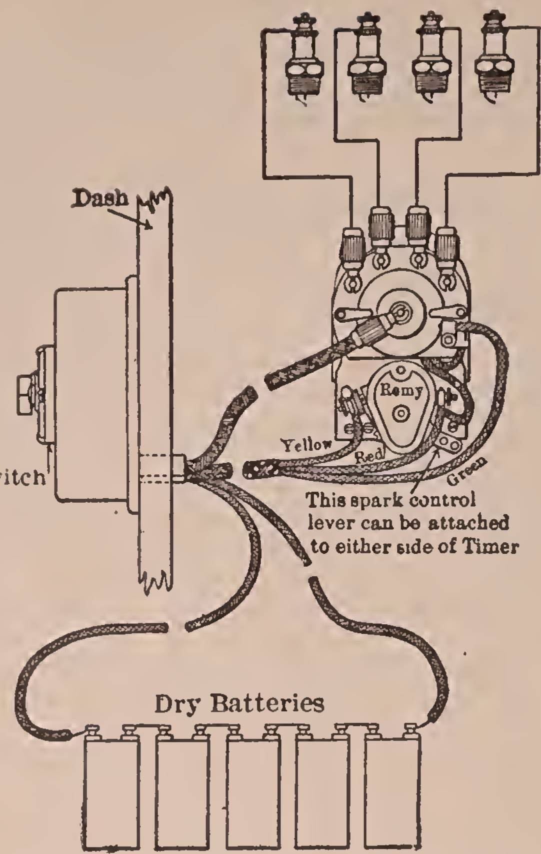


Fig. 71—End view of the Remy magneto shown in Fig. 70.

All this is shown in the diagram, Fig. 72, previously mentioned, and the drawing, Fig. 70, which shows the components of the same system in a more easily recognized form. In the former, it will be noted that a push button is indicated. This is for starting on the spark, as it is called. When the motor has been running and it comes time to stop, the driver shuts off his spark but opens the throttle. Thus, the motor in slowing down and stopping draws into the cylinders a full charge of rich and readily combustible gas. When it is next desired to start, the switch is thrown to the battery position, the throttle and spark finger levers set right for running, and the push button pressed. This sends the battery current—of high amperage, as pointed out previously—through the coil and distributor to the spark plugs. The construction of the interrupter is such that this momentary contact of the button will coincide with a break in the current furnished, this being the condition necessary for the generation of a high-tension current in the coil. Of course, the current flowing through the high-tension distributor can go only to the cylinder in which the firing point has been reached, consequently the spark will occur only in the cylinder which is fitted to receive it—is waiting for it, so to speak.

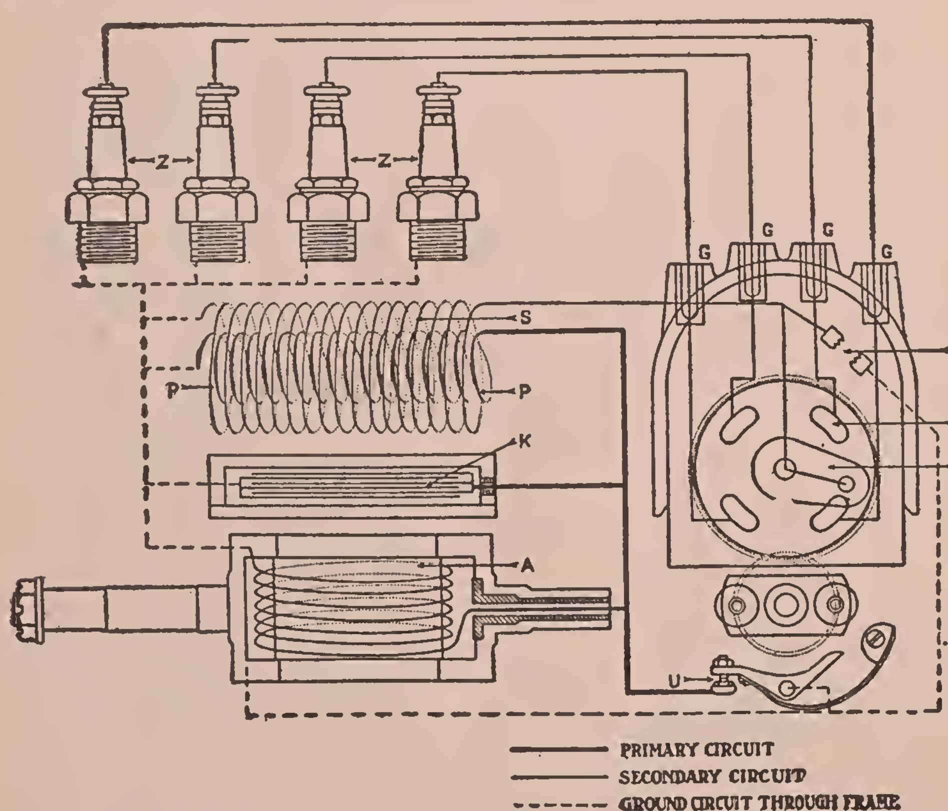


Fig. 72—The Bosch high tension magneto carries its own condenser and coil.

This covers all of the ordinary ignition parts and their functions. Of course, there are a large number of special pieces of apparatus fitted for use with special systems, but it is considered that the space can be used to better advantage than describing all of

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when there is some gasoline inside. This will drive off a combustible vapor, and it can be ignited at the hole. If the float is found to have a large number of holes—that is, if it is porous—a new one must be substituted, unless the owner wishes to have it copper plated, which will close the holes effectually.

**226. Does the shape of the inlet pipe have any bearing on the mixture?** Very little, if any. Designers aim to make the shape such that the distances traveled by the gases from the vaporizing chamber to the different cylinders is equal in length and in number and shape of turns. It is considered that were this not the case, more gas might be drawn to the cylinder which had the shortest or least bent pipes. Consequently, the other one or ones which has the longest and most bent pipes would get much less gas. This would be a cumulative action, and ultimately the difference would be such as to produce irregular action.

**227. Aside from this, is there any special point observed in laying out inlet pipes?** None, except to have a large enough opening to pass the greatest possible amount of gas. The permissible speed at which the gases may travel is fixed, and from this and the quantity maximum, the size of the pipe is proportioned.

**228. Is the automatic or suction valve used for engine inlets?** No, it went out of use for automobile engines about five years, and for motorcycles and motorboat engines at least

these in detail, since if one were described, it would be only fair to describe the others with an equal amount of detail.

**CARBURETION** is but a method of converting a liquid into a gas, as in the liquid form the fuel cannot be burned inside the cylinders of an automobile, while as a gas, carrying the proper proportion of oxygen with it for burning, it can be used inside the motor. The carburetor is a more or less simple device for converting the liquid to a gas and adding to it the necessary quantity of oxygen in the form of atmospheric air.

In general, there are three types of devices for doing this, these varying according to the method followed. They are:

1. The surface carburetor, in which the air passes across the surface of a pool of fuel, absorbing a quantity of it in passing.
2. The ebullition or filtering carburetor, in which the air is passed up through the body of fuel from below in the form of bubbles, these carrying with them more or less of the fuel and converting this into a vapor above the main body of liquid.
3. The float feed, or spraying carburetor, in which the suction of the engine draws the fuel in the form of a very fine spray past a spray nozzle, to which the liquid has been raised by means of a float in a separate chamber.

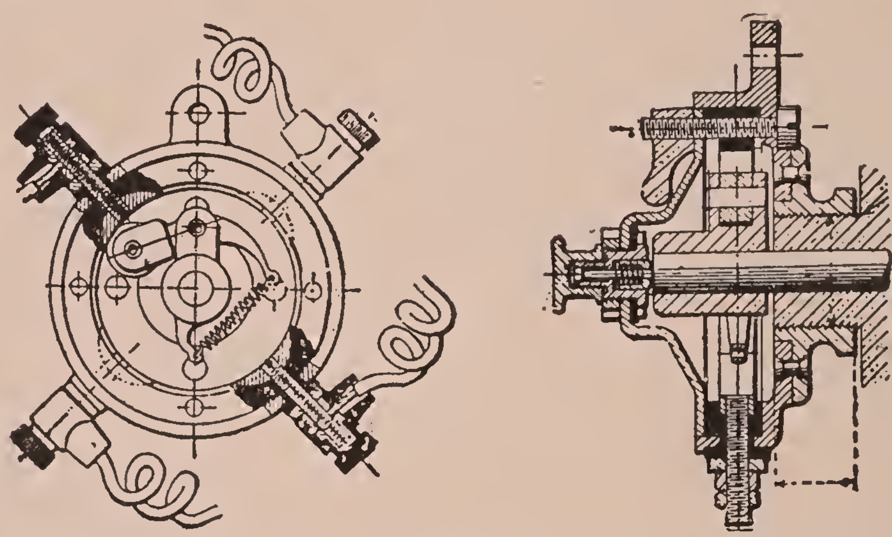

Fig. 73—Timer of the Roller type for a four-cylinder Motor.

Both of the first two are older forms, now discarded, but a relic of the first named is to be found in the so-called puddle type of vaporizer, of which Holley—and to some extent, Duryea and Bennett—are examples. All modern carburetors come in the third class, the differences lying in the details and the arrangement of parts. In the following explanations, the function of and necessity for the various parts will be pointed out, using some simple form, after which a number of well-known devices which have been more than ordinarily successful will be presented to show the different arrangements.

In general, carburetors have a fuel or float chamber and a vaporizing chamber with a passage or passages connecting the two and another passage or passages connecting the latter with the inlet pipe to the motor cylinders. Thus, as shown in the sketch, Fig. 74, which represents an elementary form of vaporizing device rather than any carburetor now made and sold, the fuel enters the bowl or cup *A*, from which it flows to the standpipe *C* through the connecting tube *B*. As the law of liquids applies, the level in the standpipe will be equal to the height in the supply chamber, as shown by the horizontal line *M-N*. This standpipe is located in the center of a large tube, the bottom end of which, *F*, is open to the inflow of air, while the top end *G* connects with the motor.

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three years ago. While simple, it was not flexible enough, nor sufficiently accurate.

**229. Will the ordinary engine burn other fuels than gasoline?** The engine will work well enough on any fuel that the carburetor can handle. It is advisable, however, to use higher compression motors on the heavier fuels, such as kerosene, alcohol, etc. This means a change in the design or construction.

**230. How does a surface carburetor work?** The gasoline is arranged in a flat chamber with a broad surface over which the entering air passes, or else with a wick dipping into the liquid, and the air passing over the top of the wick.

**231. Was this very simple device satisfactory?** Yes, on the unusually light and very volatile fuels of the earlier days; it would not work on 1914 fuels.

**232. Was this form economical?** Very much so; this was its chief advantage, even over its marked simplicity.

**233. If an engine has a carburetor, the needle valve of which is too large for the other parts, how can this be remedied?** By contracting the top of the fuel orifice so that the hole will be made somewhat smaller. This can be done by peening with a hammer, using a light one and great care.

**234. In case this work is done quickly, and the hole made too small?** A small drill or

The fuel flow being constant through the tube *C*, there would be times when this would furnish too much liquid and at other times too little. In the former instance, gasoline would be wasted, and in the latter the engine would not get enough, consequently the needle valve *H* is introduced. This has a tapered upper end which corresponds more or less closely with the tapered inner surface of the upper end of the opening in the tube *C*. When the needle is screwed down rather low, as shown, the effect is to give an unrestricted passage, about the same as if there were no needle there. If, on the other hand, less fuel were desired, the needle would be screwed upward until it lessened the space through which the liquid could pass and thus restrict the flow. Obviously, it could be made more or less as desired, since the simple twist of the handle gives a different sized opening and consequently a different flow of fuel.

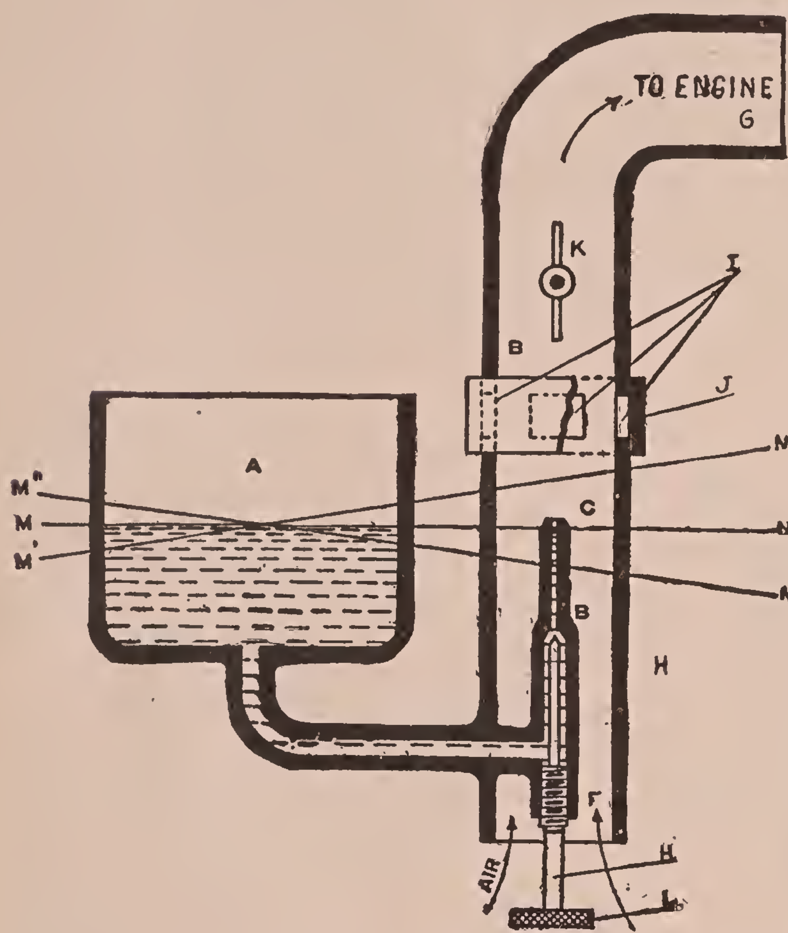

Fig. 74—Outline sketch of basic vaporizing device.

In practice it has been found best to have the level in the supply chamber such as to bring the fuel up to within 1 millimeter (about 5/128 of an inch, or slightly more than 1/32 inch) of the top of the spray nozzle. In this position, the slightest suction will raise it into the chamber surrounding the nozzle. The air is drawn in from the bottom of the larger pipe and mixes with the spray of fuel raised at the top of *C*, thus creating a gasoline vapor. It is possible—in fact, probable—that the right quantity of air is not present for complete combustion when the mixture reaches the cylinders, so additional air ports are cut in the walls of the vaporizing tube above the top of the jet, as at *I, I*. The same amount of additional air is not needed at all times, as, for instance, early in the morning and in the evening the air contains more moisture and less of it is needed. During the day, the air is more dry, and a greater quantity is required. For these reasons, the additional or auxiliary air passages must be varied. Thus, those at *I* are covered by a sleeve *J*, which has similar ports cut in it and which may be turned around.

When turned so that the ports register exactly, the full amount of air enters, but when this sleeve is turned so that a part of the opening is cut off, a smaller amount is admitted. This might be called the auxiliary air adjustment. Again, the engine at low speeds requires less vapor than when running at high rates or when working hard. Obviously it is necessary to vary the amount which is admitted to the engine without, however, disturbing to any great extent the manner in which the vapor is created and its continuous creation regardless of the amount

reamer may be run through the hole, but care should be used to select a size smaller than the original hole, otherwise all the work will have been wasted. As these holes are very minute, this work should be done with great pains, in order to get an accurate job.

**235. What is a better plan than trying to fix this yourself?** Apply to the maker for a new nozzle. It is doubtful if any amateur could do this work with sufficient accuracy; the upper surface of the nozzle would be ragged and give an irregular spray. Any one could screw out one nozzle and screw another in its place.

**236. What good does heating the air do?** Carburetion is a chemical reaction which requires heat. Ordinarily this is taken from the surrounding atmosphere, but in cold weather when there is no heat available, it is best to supply this.

**237. What are the best ways of doing this?** By means of hot air from the exhaust pipes, supplied into the main air opening, or by hot water from the engine-cooling system, piped around the vaporizing chamber.

**238. Which is preferable?** The water is more thorough, but requires more apparatus, costs more, adds more to the weight of the car.

**239. In burning heavier fuels, is the ordinary heating means sufficient?** No additional heat must be supplied. In this case, good results may be obtained by using both air and water methods at once.

used. This is done by introducing into the inlet pipe a throttle valve *K*. In its simplest form, this is a round disc of the same diameter as the inside of the pipe, mounted on a movable shaft in such a manner that it may be turned to any desired position between a full right angle to the pipe, in which position it cuts off the communication entirely, to a parallel with the pipe, in which position the full area of the opening is available. In the former position, the gas is cut off, none being able to pass to the engine, and the latter cannot run. In the latter position, the maximum amount is passing and the engine should be running at its highest possible speed. This is spoken of as the throttle, but the type of controlling valve shown and described is known as a butterfly valve.

What has been described previously as the auxiliary air valve, with its variable opening, is simply the working out of what Commodore Krebs laid down as a fundamental law of carburetion, upon the occasion of his development of the first float-feed carburetor back in the early nineties. He said then—and it is equally as true to-day—that when the air for vaporization of a liquid fuel is admitted to the carbureting device in two different quantities through two different orifices, if one of these be fixed, the other must be variable. In practice, the primary air opening is fixed in size; therefore, the auxiliary air port must be a variable one.

In addition to the parts shown and described in connection with this simple device, there are but few parts needed to complete any modern device. These are the *float,* for controlling the fuel level and flow to the spray nozzle; the *priming valve,* for depressing the float in order to furnish an excess of fuel for starting purposes; the *heating arrangement,* for making vaporization more easy in cold weather; additional *fuel nozzles* in certain types with the modifications which these require; the *strainer,* for clearing the fuel, as it flows in, of particles of dirt or other foreign matter; the *inter-connecting levers,* for those vaporizers in which the throttle and the air valve are connected together; the *bypass,* for supplying pure air above the throttle on certain forms, and such *springs, cams, levers, dashpots* and other mechanical features as the arrangement and working of the device calls for.

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**CARBURETOR'S OPERATION SIMILAR.**

With these exceptions, all modern carburetors are more or less alike. True, they are arranged radically different, but when these differences are analyzed closely they will be found to consist mainly of the natural differences brought on by moving a necessary part from a position at the side to one at the top or from changing two parts from the sides to one at the top and the other at the bottom, etc.

Taking these up in order, the float in common use is of two kinds: The shellac-covered cork, and the hollow metal, usually copper. The former has the disadvantage that the shellac may be worn or scraped off, after which it is but a question of time before the whole thing becomes fuel soaked and consequently sinks instead of floating, and thus becomes useless. The hollow-metal form has a similar disadvantage, in that it must be joined or united to itself somewhere, and this seam is liable to open. When it does, the float leaks, the fuel seeps into the interior, and ultimately fills the inner opening, after which this form of float will

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**171A. What is a storage battery?** It is a form in which the current supply may be renewed after it has been entirely used up, by charging from some source of current. In the sense in which the word storage is used, it is not a storage batttery at all, but the general idea is that the charging process stores current in it, and that it may be used until this is gone, when more must be stored in it.

**172A. How does it differ from the dry battery?** The active electrolyte is a liquid and may be spilled, while in a dry battery it is a semi-fluid and may be sealed up tightly. The storage battery, on the other hand, must be left open at the top.

**173A. What harm will it do to spill this liquid?** Being an acid, although a mild one, it will eat into and corrode everything with which it comes in contact. Moreover, the battery itself will not work well with the level of the liquid lowered very much.

**174A. How is the loss of liquid replaced?** By adding distilled water in small quantities, but at regular intervals so that the level does not get very low and if so, for a very short time only.

**175A. In what way can a storage battery be recharged?** From any one of three: from a direct current supply, as a house lighting system; from a source of alternating current,

not float and consequently is useless also. With the improvement in welding devices and processes, this latter difficulty is being overcome rapidly, the result being that the majority of different makes use the hollow-metal type.

This is not to say that there is any drawback in either form, for there is not; the use of either will give equally good results, and the selection of one of these two forms is more or less a matter of personal preference.

In general, the fuel enters the float chamber at the bottom or the top. In the latter case, the most common, by the way, the float is arranged so that its rising depresses the float valve so that at a certain predetermined level the inflow is cut off, until the outflow to the vaporizing chamber floats the controlling member down low enough to open the valve again and thus admit more fuel. Considering the bottom entrance case, the fuel is cut off in one of four ways: The upper and outer surfaces of the float connect with one end of a series (usually but two) of toggle levers, the other end of which is fastened to the float-valve spindle; the float itself carries the valve spindle which has an inverted, cone-shaped lower extremity, this seating at a certain height on a cone-shaped surface in the inlet pipe; the toggle arrangement described first is inverted and placed at the bottom, while a spring is added which tends to hold the needle down and thus holds the arms of the toggle against the bottom of the float. Otherwise, the rising of the float would lift it off of these arms, and the arrangement would not work; the side of the float is fastened to a short lever, which is pivoted in the carburetor casing at the middle, its other end surrounding and actuating the needle valve. In the first three types the needle may be on the vertical center line of float and float chamber; in the last named, it cannot. Sometimes, however, this last is an advantage for one reason or another.

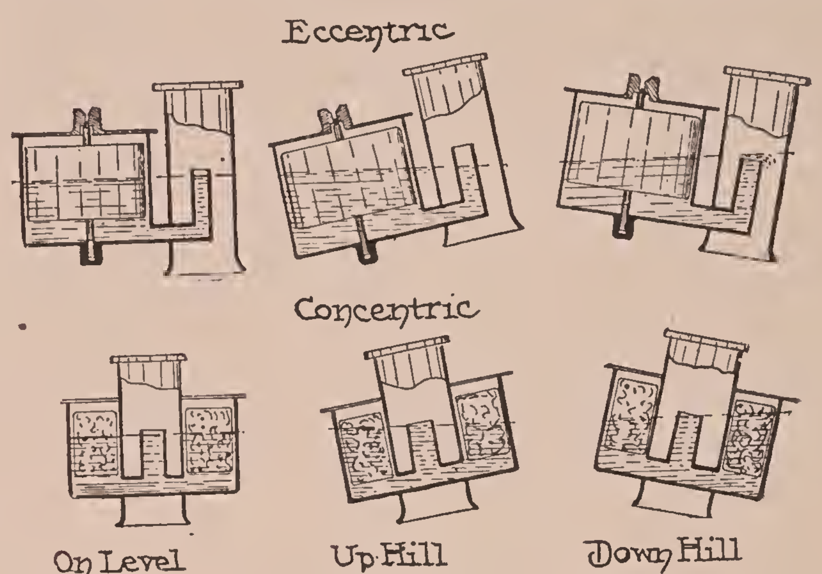


Fig. 75—The two types of float chamber location, indicating the advantages of each and the disadvantages.

Another point in the design and use of floats: Their position relative to the vaporizing chamber, where the spray nozzle is located, is highly important, for this determines, under certain conditions, whether there will be any flow of fuel or not. Thus the float chamber with its float inside may be concentric with the vaporizing chamber—that is, surrounding it—or it may be set off to one side. If the float chamber be set in front of or back of the vaporizing space and the spray needle, in climbing or descnding a hill the latter will be either starved of fuel or else overflowed with it, according to where the float is. This is brought about by the difference in level of the liquid, as pointed out in Fig. 75. Unfortunately, the same is true when the offset float chamber is set at the side, for on certain highly crowned roads, when one wheel may be at least 10 to 12 inches lower than the other, the needle is again starved or flooded, as the case may be.

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through the medium of a rectifier; and by means of a so-called primary cell.

**176A. Which is the best?** One is as good as the others, the usual charging including one of the first two methods, primarily because they are more handy, and in adition, more quickly available.

**177A. Which is the quickest?** There is no such thing as charging a storage battery quickly. When this is done, the plates are sure to be buckled or injured otherwise. All three charge at the same rate.

**178A. How is the voltage of a house lighting system adjusted to battery charging?** The voltage makes little or no difference, beyond the knowledge that it is higher than 10.

**179A. If that is the case, with what is the operator concerned?** With the amperage or quantity to be put in.

**180A. How is this determined?** In charging the arrangement is such that only so much can pass through to the battery being charged. This is maintained until the battery has received a full or complete charge, its size and character determining this.

**181A. What is that arrangement, in the case of using a house lighting current of, say, 110 volts?** Carbon filament lamps are introduced into the circuit so that the current must pass through them first. The ordinary 16 candlepower lamp will allow but ½ ampere to flow through it, while a 32 candle-

This would seem to point to the concentric form as the only desirable one, and yet its lack of accessibility, as compared with the separate chamber, is such a serious disadvantage as to almost overbalance this.

**THE PRIMING VALVE OR ROD** does not show so much difference from one device to another. In general, it consists of a short, straight, round rod set so as to point directly at an edge of the float, but held away from this by means of a spring. To prime, the driver lifts the hood and presses this rod down against the spring pressure. This de-

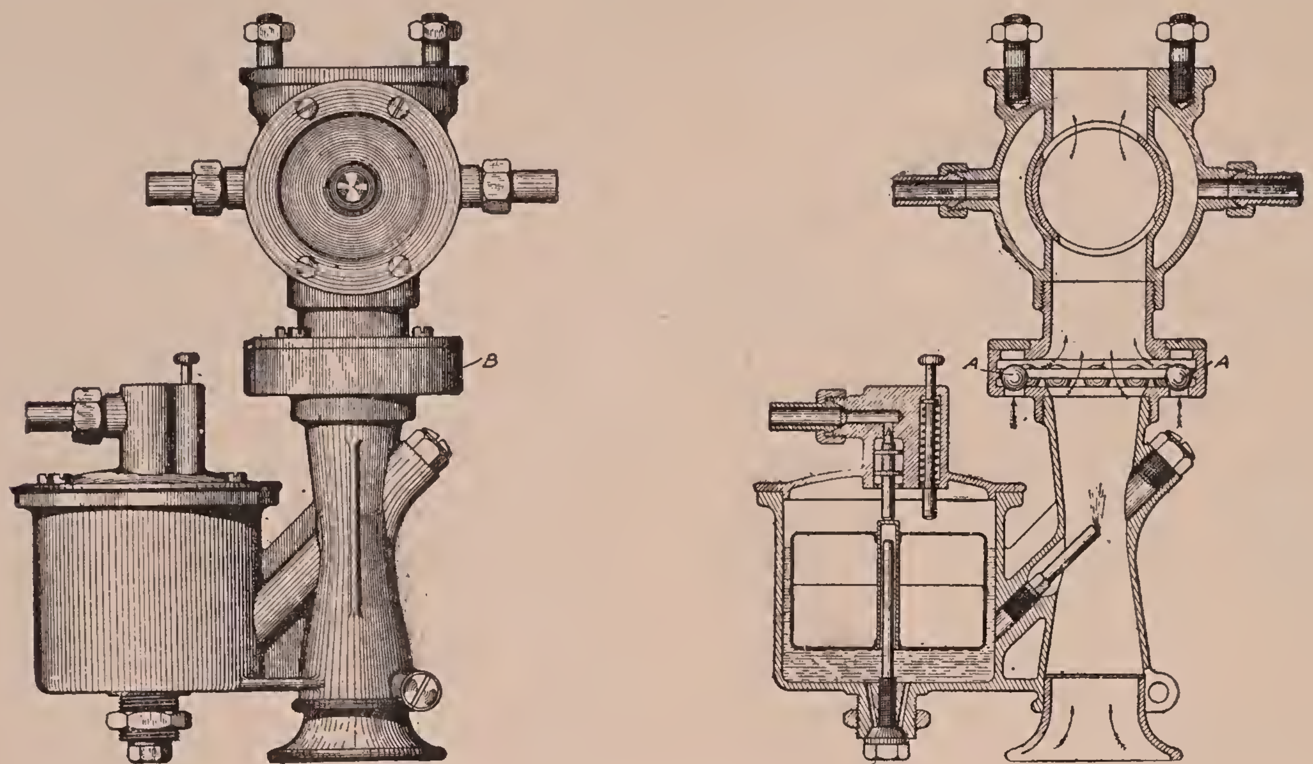


Fig. 76—The G and A carburetor in elevation and section—note the ball air valves.

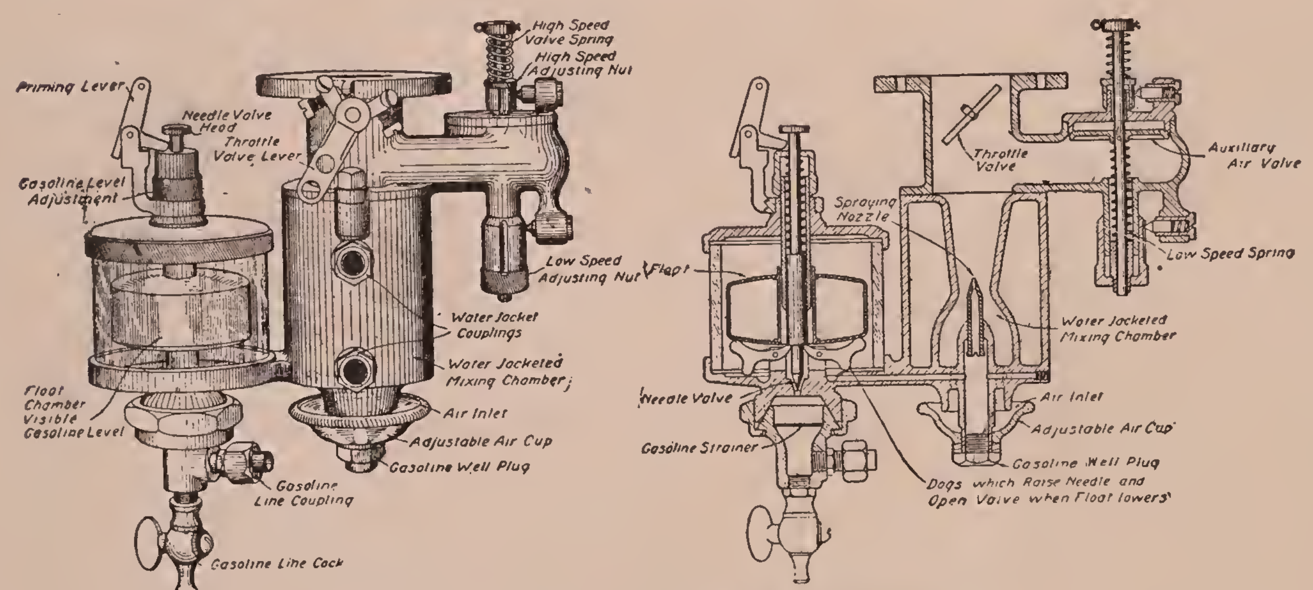


Fig. 77—Elevation and section of the Stromberg carburetor in which a glass float chamber is utilized.

presses the float to such a point that an excess of fuel flows into the float chamber and thence to the spray nozzle. In this way, a surplus of fuel is made available,

power lamp will let a current of 1 ampere pass, and a 64, 2 amperes, etc. By connecting in as many lamps as is needed to make up the current required for the battery, the system is completed and the battery may be charged by simply turning on the "juice," then allowing it to stand until the charge is complete.

**182A. What is the usual charging rate for storage batteries?** About 3 amperes is a good rate, but the ordinary battery will stand 4 without any damage, and if new, in good condition, and the charge is required as quickly as possible, 5 amperes can be used when the charging is conducted by one able to watch it.

**183A. How are these various amounts obtained?** As pointed out previously, a 16-candlepower carbon lamp on a 110-volt circuit will let ½ ampere pass. Then to obtain 3 amperes it is necessary to have 6 lamps; for 4 amperes 8 lamps of this size, and for 5, 10 lamps.

**184A. Is it wise to use all lamps of the same size?** Yes and no. Where they are of different sizes, the current may be varied to suit conditions. Thus, if the charge was started at 5 amperes, and this was found to be too high for that particular battery, the removal of a single lamp would reduce it to 4½. If smaller lamps or smaller and larger ones were used in combinations, it

which insures the overrich mixture necessary for easy and quick starting. In order to prevent or avoid the necessity for lifting the hood in order to get at this priming valve, they are now made with a short bent lever, pivoted in such a position that one arm rests on the top of the primer in much the same way the finger would. Then a cord or wire is attached to the lower or vertical end of the lever, this being run forward through the radiator or along the frame with some form of ring or lever at the extremity. Then, when cranking, the driver can operate the primer from the front of the car by pulling this ring or moving the lever.

In some cases, when the float is concentric with the float valve, the latter is carried through the former and up through the top of the float chamber so as to project above it for some distance. In this type, it is possible to have the primer work directly upon the float valve stem instead of indirectly through the float, as just described. By having the previously described bent lever work the float valve stem up or down, as the case might be, the desired priming action or enriching of the fuel is effected.

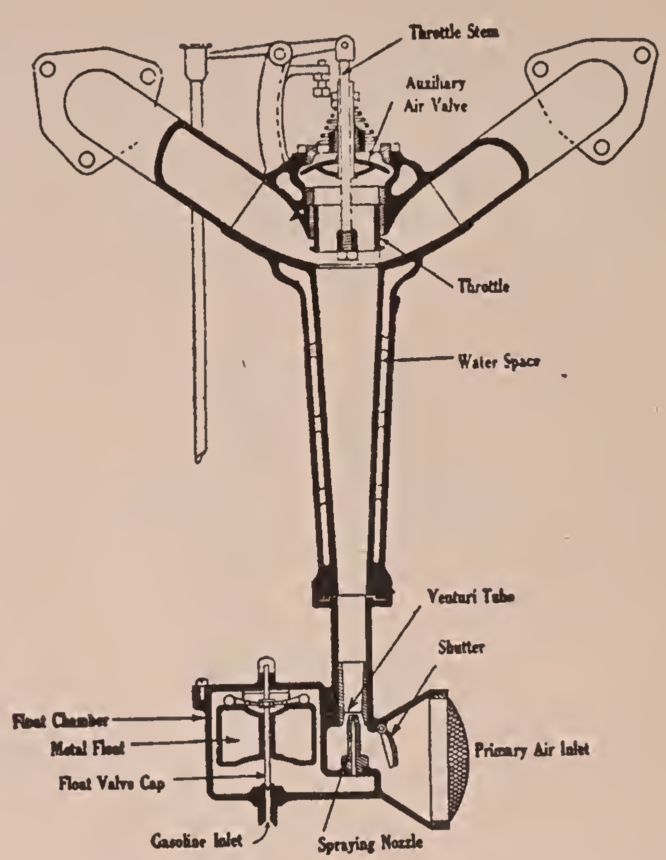

Fig. 78—The Peerless carburetor is situated at the bottom of a long vaporizing tube, water jacketed.

In one American vaporizer there is a secondary valve set into the fuel inflow passage in such a way that it may be operated independently of the float and its valve. The arrangement of this is such that it is closed normally, but when opened it allows extra fuel to flow and to pass into the vaporizing chamber despite the position or action of the float and its valve. The priming connections are attached to this, which is called the priming valve, and is used for priming only.

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**HEATING THE FUEL** has the effect of making possible vaporization at times and under conditions which without the heating would be impossible or at least very difficult. Thus in the winter time and during the cold months, starting is most difficult, and with some devices practically impossible, while during the very cold days continuous running is difficult. To supply this need, heat is supplied from some convenient source. The exhaust is one of these sources, and the cooling water the other. Whichever one of these is used, it is supplied to the jacket which surrounds the vaporizing chamber or the inlet pipe just above this.

Thus, Fig. 76 represents a vaporizer (G. & A.) in which water is used for heating the upper portion, just above the vaporizing chamber and just above the point where the additional air is admitted. As this is a most successful device, the utility of this particular position cannot be gainsayed, although the majority

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would be possible to try 4¾ first, and then if that was found to be too high, 4½ subsequently.

**185A. How could this be managed?** By using 3 32-candlepower lamps, 2 16s and 4 8s, it would be possible to get any combination by quarters from 5 amperes down to ¼. Similarly, with 8 16s and 4 8s, except when it came to reducing the flow by a large quantity, it would mean taking out a number of lamps.

**186A. How much current should be put into a battery?** Every battery has a rating, according to the number of ampere hours of output which characterize it. At least this amount must be put in. The ampere-hours of input are found by multiplying the steady flow by the number of hours the battery is on charge, or to put it in a more practical way, the number of hours the battery must be charged is found by dividing its ampere-hour capacity by the number of amperes allowed to flow.

**187A. Give a practical example of this?** A 6-60 is a battery which is used very widely, namely a 60-ampere hour unit which works at 6 volts. To charge this at a 3 ampere rate would require 20 hours, at a 4 ampere rate 15 hours, and at a 5 ampere rate 12 hours. Thus, in the first case (at 3 amperes), if it were put on the circuit at 6 o'clock on one night it would not be fully charged until 2 o'clock the following afternoon, and would not require any attention whatever until about noon. In the second case (at 4 amperes) it would have to be on the circuit

of makers prefer the water right around the jet and vaporizing chamber as shown in Fig. 77. This shows the Stromberg device in both section and elevation, the former indicating the position and arrangement of the water jacket, while the latter shows the inlet and outlet connections for the water.

Another method of differing from that of Fig. 76 lies in the use of a very long inlet pipe with the carburetor at the bottom and the auxiliary air valve at the top close to the cylinders, with the heating water arranged around the upper portion only. This method is used by Peerless, as shown in Fig. 78.

When the exhaust is utilized for heating purposes, larger passages are left generally, or metal bodies introduced therein to hold the heat. Both plans are followed on the Longuemare device, seen in Fig. 79. This is one of the most successful of the many French vaporizers, although the particular device illustrated was intended to be used for alcohol as well as gasoline.

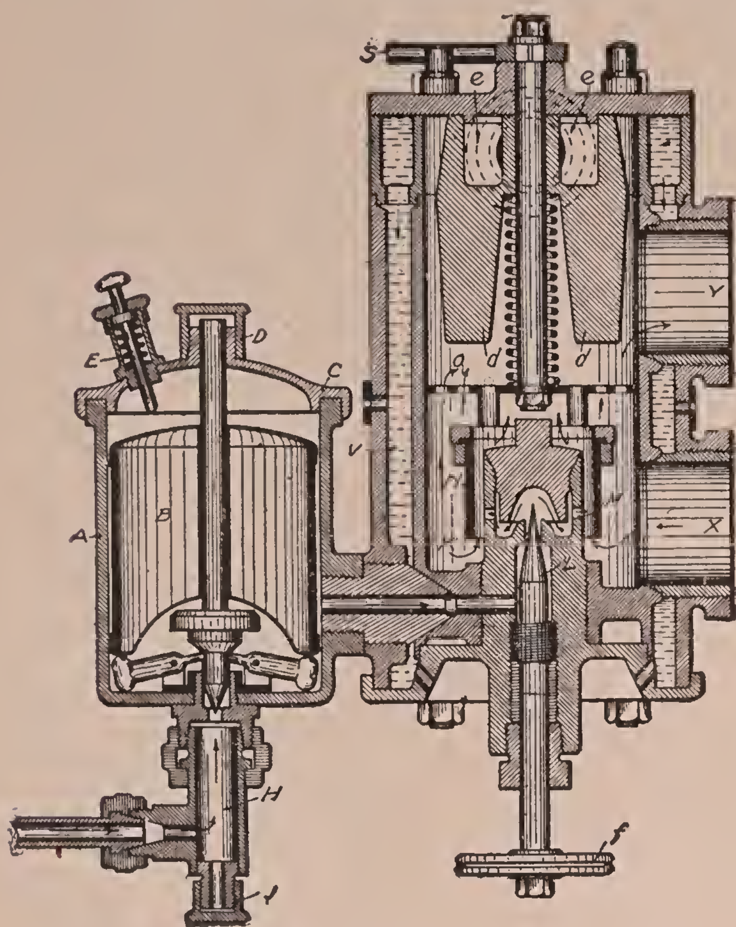

Fig. 79—The Longuemare carburetor which will utilize any heavy fuel, as alcohol, kerosene, benzol, etc.

In this the jacket may be seen as well as the heating bodies of metal. A somewhat similar method of heating by exhaust is used on the Holley kerosene carburetor, shown at Fig. 80. The vaporization is not completed in this, however, until in the upper portion, where the auxiliary air is added, and it will be noted that the exhaust heating chamber is carried up as close to this point as the construction will allow.

It will be noted, moreover, that the exhaust gases enter at the bottom, so that they present the maximum amount of heat to the fuel to be vaporized at the point where it is most needed, namely, at the beginning of vaporization. The gases are hottest when just leaving the cylinders, and for this reason are immediately, with as little piping as possible, brought against the liquid fuel at the point where vaporization commences.

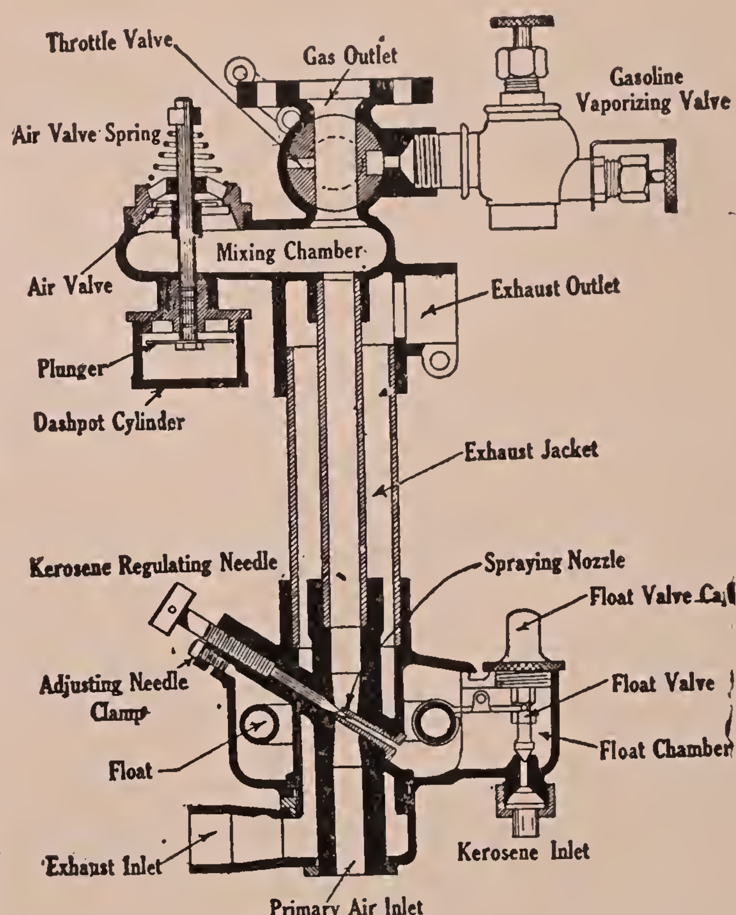


Fig. 80—Section through the Holley kerosene vaporizer, in which an extended exhaust jacket is used.

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from the same time, 6 o'clock one night until 9 the next morning, and would not need any attention until daybreak at least, taking this at 6:30 a. m.; in the third case (at 5 amperes) it would have to be on charge from 6 in the evening until the same time the next morning. In this case a better plan would be to put it on charge at 8 in the evening, so that it could be inspected at 6 the next morning and again at 7, the more rapid rate requiring closer watching.

**188A. Is there any way of telling when a battery is almost charged, aside from figuring out how long a charge it should have?** Ordinarily, the positive plates in a lead type of battery are of a chocolate or velvety brown color, while the negative plates have the color of spongy lead, which is a light gray. When discharged, the two colors are materially changed, the gray plates have a good deal of brown in them and present a dulled or mouldy appearance. Similarly, the positives lose their characteristic brown color and show a somewhat similar muddy look. As the charging proceeds, and particularly as it approaches completion, each set of plates begins to clear up and resume its natural and normal color.

**189A. Is this color alone a perfect test?** No. Several hours before the charge is actually completed, these colors are so nearly right as to deceive any amateur.

## HEATING THE AIR

admitted has about the same influence, except that it adds the heat internally instead of externally as in the other methods. This is followed by a number of different firms; in fact, a few years ago when better fuel was available it was used by the majority. There are two methods of doing this: Heating the primary air, or heating the auxiliary air. The former should be the more efficient, since if the warm air be added at the start when heat is most needed, vaporization should start more quickly and proceed with more rapidity. In the vaporizer shown in Fig. 81, the additional air is warmed, the pipe at the upper right extending on to the exhaust manifold, or elsewhere where much heat is available. As will be noted, a sleeve is set around the lower end of this. It may be turned, and when it is so turned that the slot in it registers with the slot in the pipe the atmospheric air will be taken directly instead of the heated air through the pipe.

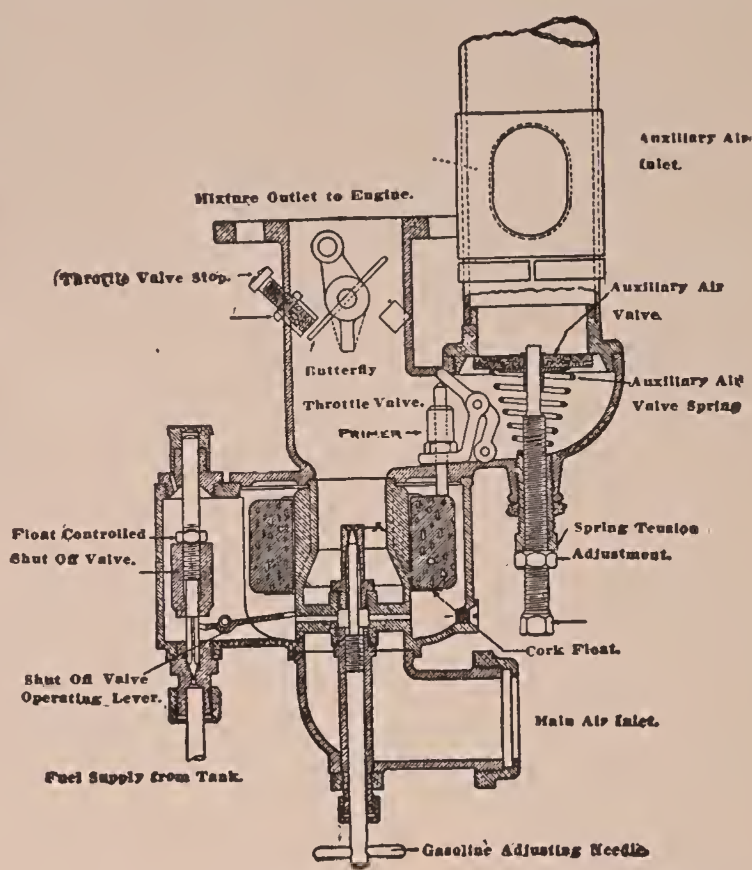


Fig. 81—A typical simple vaporizer in section, illustrating particularly the concentric float.

In a vaporizer like that shown in Fig. 82 (Kingston), the primary air is preheated, the pipe at the left, marked primary air inlet, being carried on up to the exhaust manifold or elsewhere. The air is heated there by the pipe itself, a loosely fitted and very much enlarged chamber connecting with the pipe to the carburetor. The air is drawn in around the edges, heated by the nearly red-hot metal and drawn into the vaporizer.

There it gets immediate action upon the fuel at the point where heat is most needed—that is, right at the point where the change from a liquid to a gas commences. By passing the air in so that it surrounds the fuel spray, rather than the opposite, a most efficient vaporizing coefficient is obtained. The additional air enters at the top, as will be noticed in the sketch, this coming in around the whole surface through the medium of a series of steel balls of various sizes, each one of which is seated in an opening to the underside of which the atmosphere has access at all times.

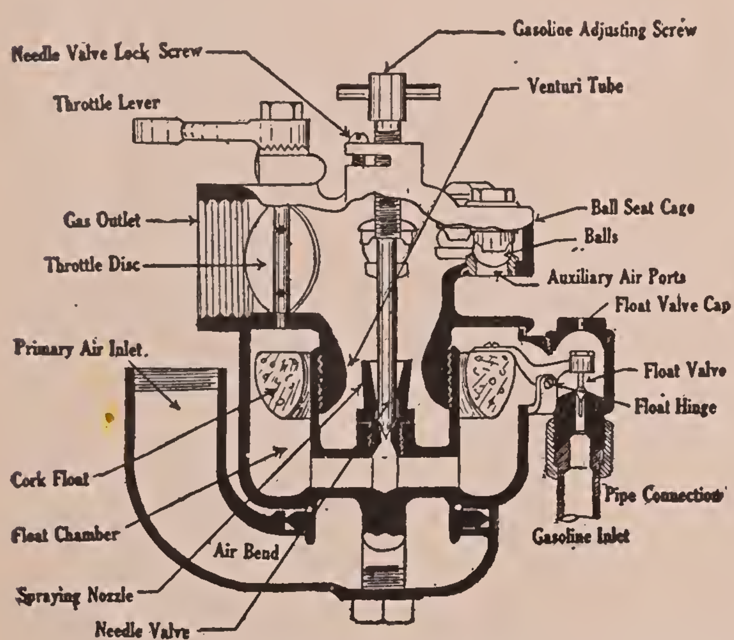


Fig. 82—Kingston carburetor in section, showing few parts and their simplicity—note ball air valves.

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**190A. What, then, is a positive test?** The specific gravity of the electrolyte should measure almost exactly 1.205. If it does not come up to this from the normal discharged figure of 1.185, the indication is that the cell is not fully charged or that it has some defect. This measurement is taken with a hydrometer, a simple device not unlike a large thermometer, and as easily used. In addition, when approaching a full charge, the gassing or giving off of the gas bubbles through the liquid electrolyte will cease. The combination of the three tests with the positive figuring in advance of its needs gives a sure way of checking the charge.

**191A. Supposing that one of these four things fell lower, yet the others showed a correct and complete charge, as, for instance, suppose the liquid showed a gravity of but 1,190?** If the acid is of the right strength and there is enough of it to cover the plates, this indicates an absolute need for further charging, regardless of what the other things indicate.

**192A. In adding acid solution, or making the same, what precautions should be observed?** The acid should be added to the water and not the opposite.

**193A. Why is this necessary?** The combination of acid and water produces heat,

**KEROSENE** is very difficult to vaporize, for the reason that so much additional heat is required. At the outset, too, practically no heat is available. For this reason, all kerosene vaporizers use the exhaust for heating purposes. In the G. C. device, shown in Fig. 83, it forms the basis of the whole device, the carburetor—if it may be called that—being incorporated in the muffler. In fact, the specially constructed muffler needs only a float chamber and suitable connections to and from this, and the inlet manifold to dispense entirely with the ordinary vaporizing device. In substance it works as follows: The fuel (kerosene) is admitted to the float chamber in the usual manner. From this, marked *g* in the end view, it flows into the interior of the muffler-vaporizer through the pipe *f*. This has a series of holes along its length, through which the fuel passes out into the tube which surrounds it. The latter is located in the upper part of an annular space between the exhaust pipe *A* and the circular tube of larger diameter *C*.

At the lower end of this same annular space another pipe (*k*) enters, this being an air supply corresponding to the usual carburetor primary air opening with a fixed area. It admits air to the annular ring and also through holes in the partition at the forward end of the inner portion of the device to the larger opening there. Herein the air is well heated before it passes back to the supply chamber *e*. By means of the heated pipes, the liquid fuel is heated to a considerable extent, so that it is changed to a vapor readily. In addition, the heated air available makes vaporization more easy. The exhaust gases pass in through *A,* turn back on themselves, and, in passing through the second annular ring, heat the exterior of the vaporizing ring. Thence, they turn back on themselves again and pass out to the air. In this way, every available degree of heat is gotten out of them before allowing them to escape. The gas formed is admitted to the inlet pipe, but with a suitable auxiliary air valve to dilute the mixture which is very rich and the use of which would not be economical. The larger passage *e,* in combination with the annular passage, makes for the storage of a considerable amount of gas, so there is an available supply, no matter what the demands of the engine may be. In this way, the vaporizer is able to furnish a sufficient supply for rapid fluctuations of speed or similar changes.

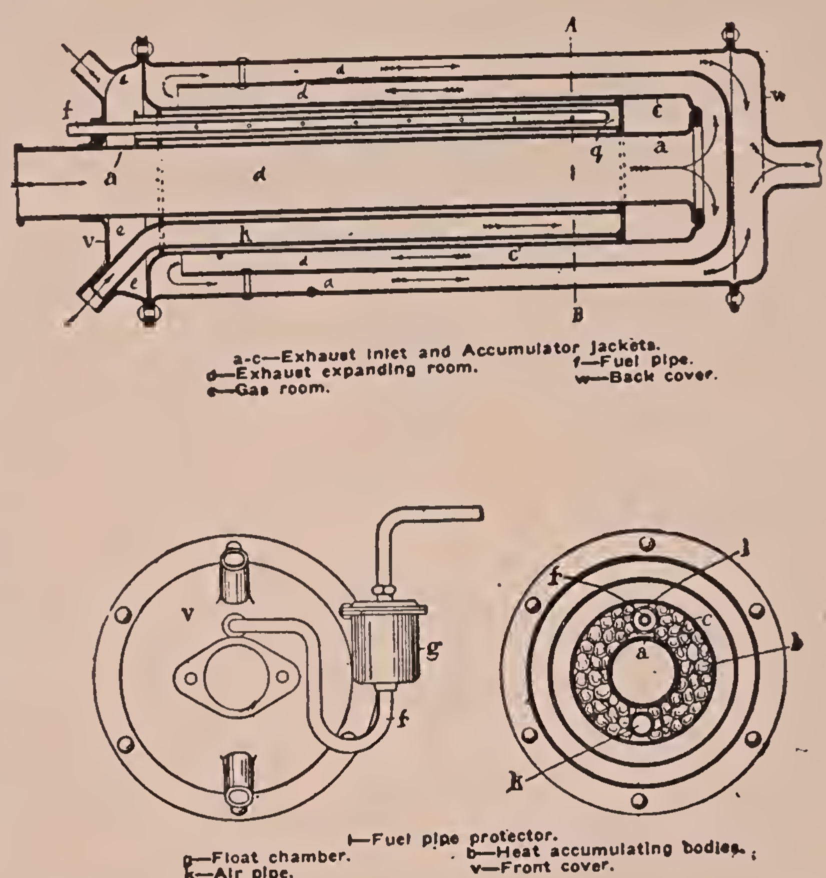


Fig. 83—Components of the G C kerosene vaporizing device, newly introduced to the American market.

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and if the water is poured into the acid such a tremendous amount of heat may be produced as to do considerable damage, causing what amounts to a small explosion.

**194A. Suppose the liquid or electrolyte falls below the top of the plates of the battery, that is there is not enough to cover them entirely?** If the solution gets more than ¼ inch below the top of the plates, they will begin to buckle. This is a cumulative action and once started, proceeds very rapidly. Moreover, when the liquid gets low it evaporates more rapidly, while the extra internal heating which is caused lowers it with additional rapidity. Hence a low level may ruin a battery very quickly.

**195A. How can battery troubles be detected, when using them for ignition of the engine, and they are approaching a condition of discharge?** When the engine starts properly and runs well, but will slow down and stop as soon as the power is applied to the propulsion of the car, that is as soon as the gear is engaged and the clutch let in, it is a pretty good sign that the battery used for ignition is almost exhausted.

**196A. Is there any particular trouble about ignition batteries which requires different or special charging methods?** When they are discharged at a low rate and thus the discharging extends over a long period of time, sulphating sets in, and it is necessary to charge at an especially slow rate in order to reduce this sulphate and bring the battery back to a normal condition.

## MULTIPLE NOZZLES

are said to give advantages which cannot be obtained in any other manner. Thus, it is claimed for them that the slowest possible speeds may be obtained using the smaller of the nozzles (when there are but two), and the smallest when there are more than two, this being sufficient to bring the machine down to a veritable crawl and still have perfect vaporization and no misfiring. On the other hand, it is claimed that with both or all nozzles working to the limit, the biggest motor constructed may be supplied with a correct and satisfactory mixture. Both these conditions are brought about without any change of adjustment, and may be had one directly after the other in ordinary use of the car. A prominent and successful advocate of this method is Stearns, whose carburetor—a two-jet form—is shown in Fig. 84.

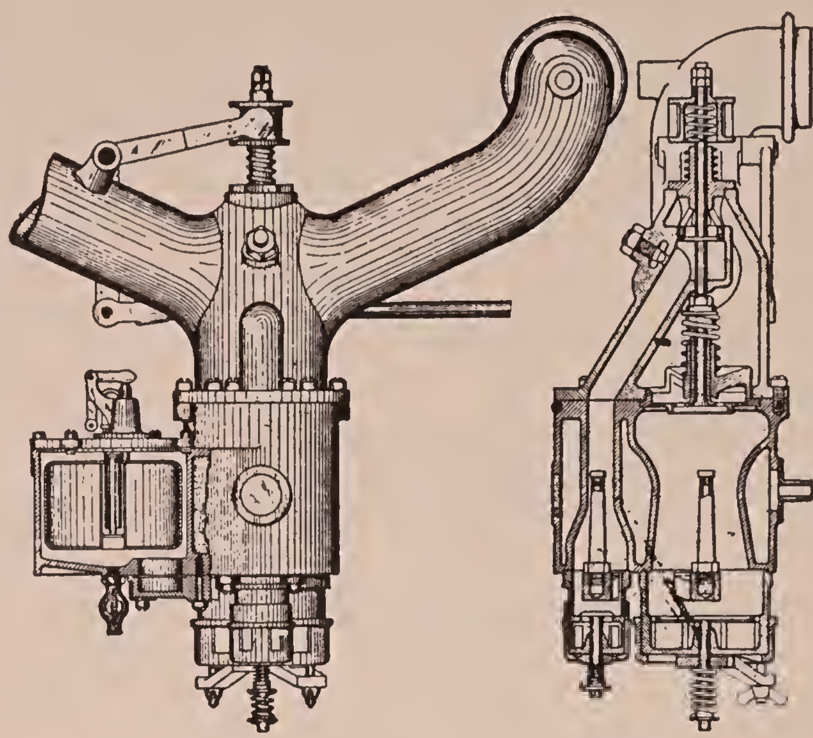

Fig. 84—The Stearns two-jet carburetor is in effect, two different sized carburetors, working separately.

In this it will be seen that there are two complete but separate vaporizing chambers, set side by side and communicating when both are in use, with a common inlet pipe. When only the smaller is being used, it is shut off from the pipe by means of the large throttle valve. Each one of these chambers contains its

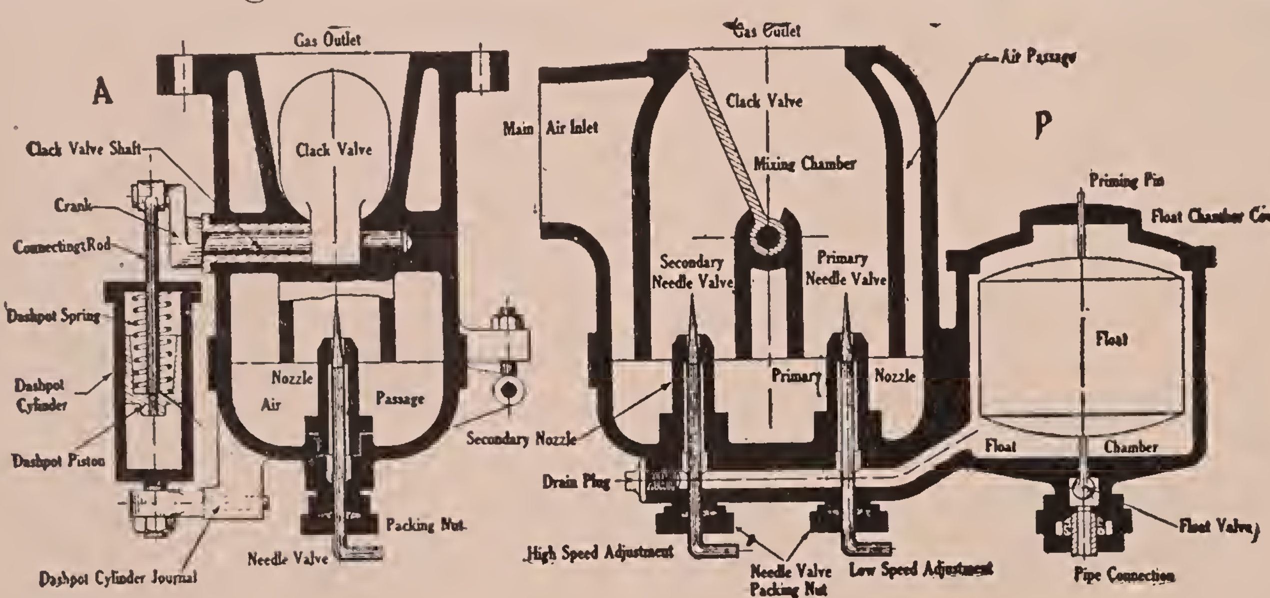


Fig. 85—Section through the Saurer device which has proven great economy.

own air valve with its individual adjustment, its own spraying nozzle with its separate flow of fuel, and the chamber itself has a shape specially designed for the size of the nozzle, the gas to be created and the amount of the supply to be furnished by it to the motor.

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**197A. Give an example to make this clear?** Suppose a completely discharged 6-60 which has sulphated badly. Normally this would be charged as pointed out at about 4 amperes an hour, taking 15 hours to do the job. The battery having been used for ignition or horn work and being badly sulphated as a result, would be charged at a 2 ampere rate and left on for twice as long or 30 hours. Or if the owner was in no hurry for it, a rate of 1½ amperes and left on for 40 hours would be even better.

**198A. When a battery and coil ignition method is used, and the battery is exhausted so far that it will not give a spark, is there any way of getting home with it?** If there are any dry cells in or on the car, no matter for what purpose they may be used, these can be disconnected from their former position, and connected up with the storage battery so as to give a combined output sufficient to operate the coil which needs 6 volts to operate, although neither one would have this alone.

**199A. Is there any other manner in which a nearly exhausted battery can be used to get home or to the nearest garage?** Sometimes, if one person sits and operates the trembler or vibrator on the coil with his finger, sufficient current will be allowed to flow to drive the car a couple of miles. There is no danger of a shock in this case, as the current is so feeble that it will not operate the vibrator itself.

**200A. Suppose the jolting of the car constantly spills the acid in a place where it**

Another device along similar lines, but constructed more simply, is the Saurer, shown in Fig. 85. Since this make of truck and touring car, botn of which use the vaporizer depicted, are well known through this country and Europe for fuel economy, the device must be a successful one. As will be seen in the sketch, there is a common fuel passage from the float chamber to the two nozzles. These have a simple form and are set at the lower end of a circular mixing chamber, the upper part of which contains a hinged clack valve, which, as drawn, cuts off the secondary valve, allowing only the primary to supply gas to the motor. As the demands of the latter rise, however, the valve is gradually drawn off of its seat and into a vertical position. As soon as it leaves the seat, so as to allow a slight opening on that side, the secondary needle valve begins to work, supplying additional mixture to the motor. At the vertical position, both are working to the fullest extent. To prevent too rapid movement of this valve and consequent fluctuation in the fuel supply, the dashpot shown at the left is used, this being connected by means of a cranked arm to the clack valve shaft. In this way the fluid in the dashpot resists the motion of the valve in either direction, so that whatever that movement is, it is positive when once started in either direction.

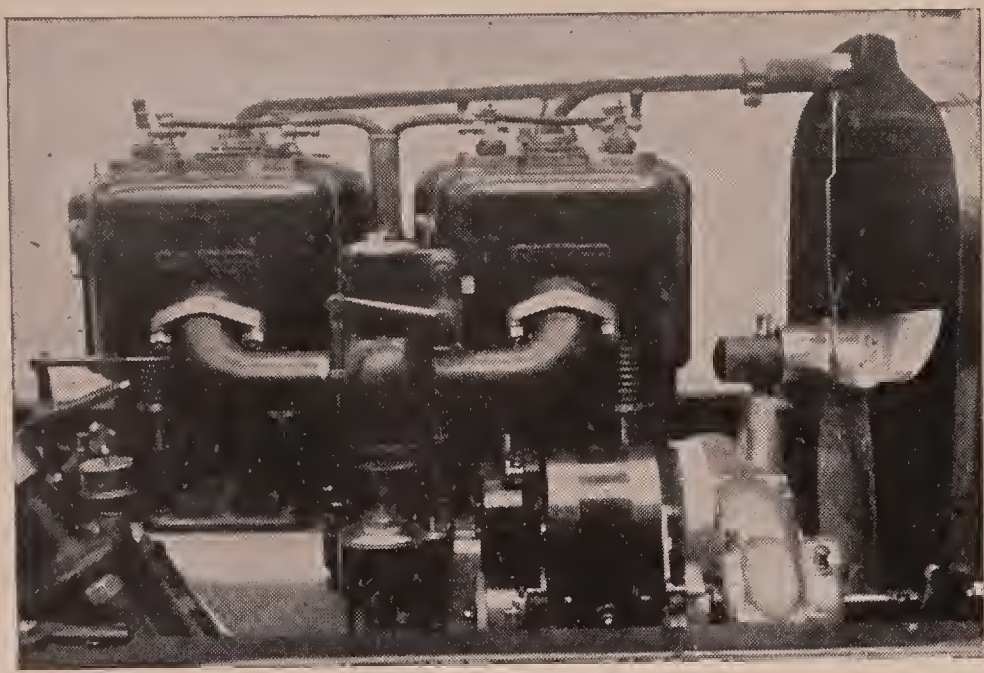
Fig. 86—Side view of a Saurer engine, showing carburetor in place.

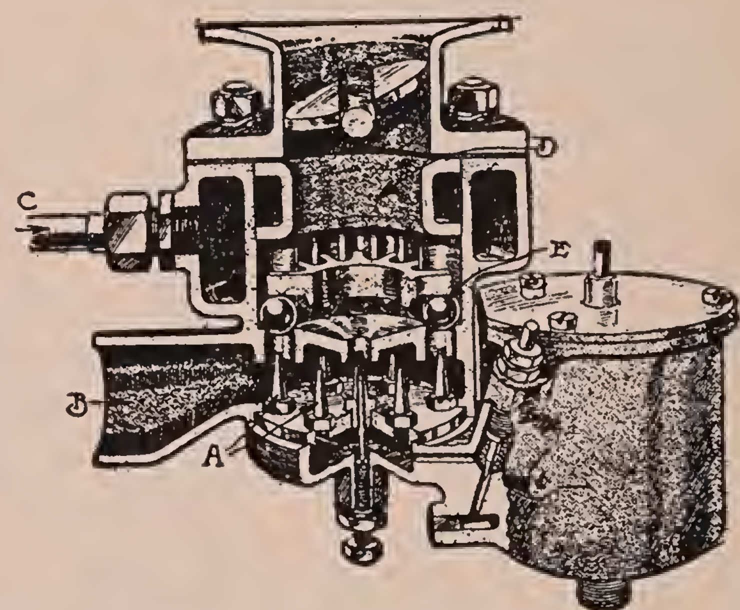

Fig. 87—Sectional view of the Daimler carburetor, remarkable for its seven jets with individual vaporizing chambers.

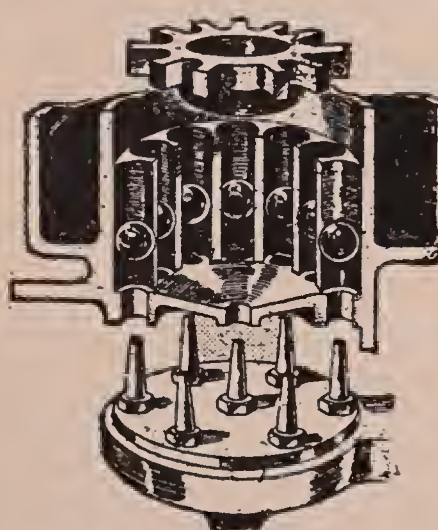
Fig. 88—Enlarged sketch of the seven Daimler nozzles.

No auxiliary air valve is fitted to the vaporizer itself nor a throttle, but both are used, being formed as a part of the inlet pipe. By examining the photograph of this carburetor in place, Fig. 86, these will be seen quite plainly, this being a 35-horsepower Saurer engine.

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**can do harm?** Spread an even layer of bicarbonate of soda over such a surface. This is a clean white powder which will do no harm, and will neutralize every bit of acid as quickly as it is spilled. Moreover, this substance is cheap, easily obtained and gives off no fumes.

**201A. What other neutral agents are used in connection with battery acids?** Ammonia is used frequently, as it is quick, positive and very cheap.

**202A. What is its greatest disadvantage?** The fumes which arise. These render it impossible to work about the immediate vicinity for some time.

**203A. What happened to a storage battery, fully charged, which is not used for some time and allowed to stand?** Its ability decreases very quickly. While it may show a normal voltage when measured, this will drop very quickly when current is used, as through a coil, coming down from 6 to 5.6 or 5.7 volts in the course of a few moments.

**204A. From this, what is a safe rule in regards to batteries not used all the time?** Have them charged very frequently, much more so than their apparent condition would warrant.

**205A. Aside from making sure of a good current supply at all times, has this plan**

Another and later device of the multiple nozzle type is an English form. This one, the Daimler, has seven jets, the carburetor as a whole being seen in Fig. 87, and the jets with their mixing chambers in Fig. 88. In the former it will be noted that a single, circular float chamber supplies fuel to a large chamber beneath the jets, so that no matter how many are working there will be a sufficient supply for all. Above this and leading into the vaporizing chamber are the seven jets, one centrally located, the others around the outside. Each jet except the central one used for slow running and starting has its own ball-controlled vaporizing passage, the movement of the balls according to the engine suction determining which ones are working and to what extent.

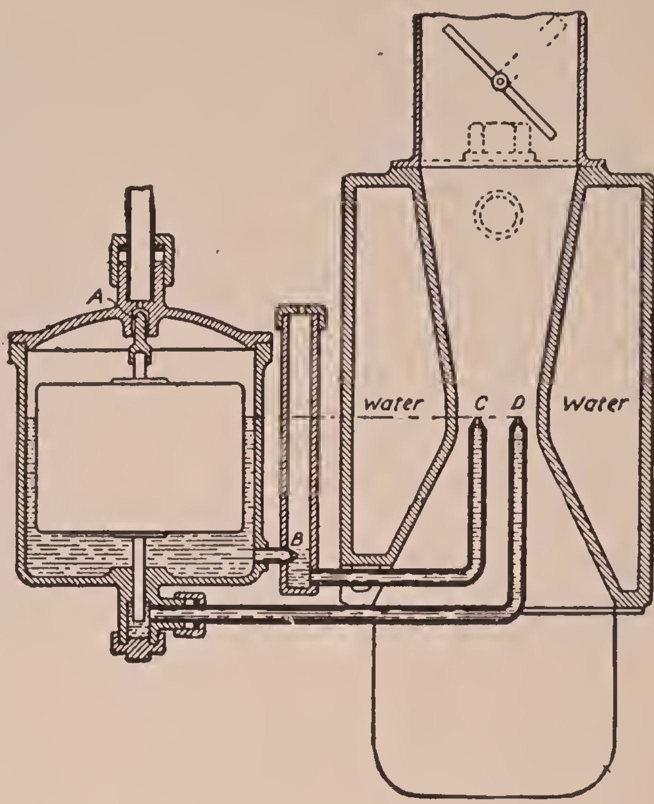


Fig. 89—Diagram to show the working of the Zenith carburetor.

In addition, there are six other air passages, also closed by the steel balls. Resting on all but one of these is a steel spider weight. In this way, normally the center jet is the only one in action, while a light suction, as at slow speeds, will lift the weight only far enough to expose one more. Subsequent stronger suction lifts the balls, and thus opens up more jets. Each ball being in its own groove, it must rise vertically, and when no longer held up by the suction, must fall back into the correct position. Just above the balls and weight a hollow distance piece is placed, which has the double effect of limiting the movement of the weight under suction and of forming a kind of venturi-shaped chamber in which the gases mingle. A butterfly throttle is used.

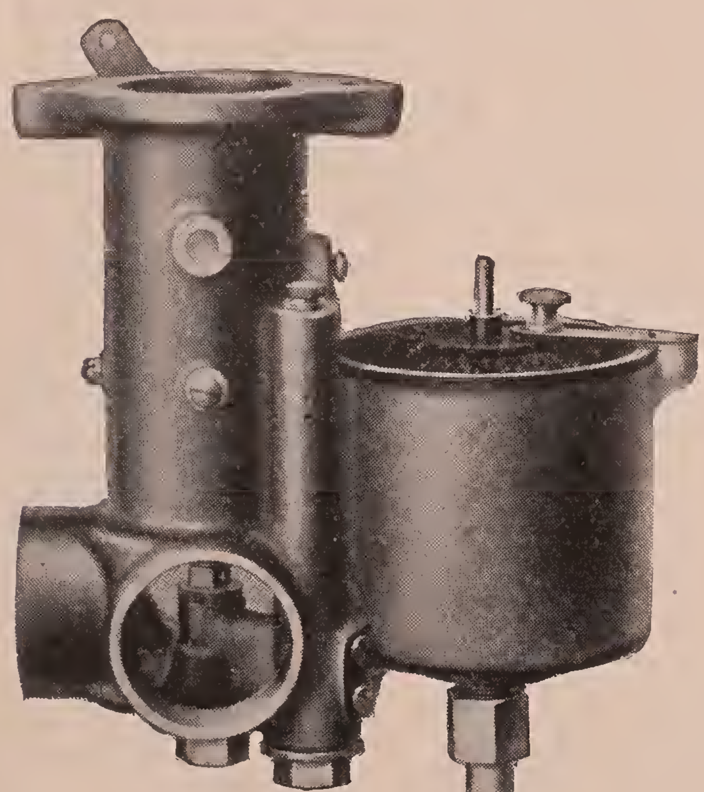

Fig. 90—Exterior of the American-made Zenith carburetor.

Although showing two standpipes, and thus coming in the same class with the foregoing—that is, possessing more than one spray nozzle—the zenith carburetor shown in section in Fig. 89, and in elevation in Fig. 90, is remarkable chiefly for the new principle which it introduced into modern vaporization. In looking at Fig. 89 closely, it will be noted that the second nozzle—namely, the one toward the left—is not connected directly with the float chamber, but that it leads from a vertical chamber or standpipe, which in turn is connected with the float chamber at the bottom. It has, in

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**any other advantages?** Yes, it is good for the battery itself, as it builds the plates up and keeps them built up, resulting in maximum efficiency. In fact, this is a good plan to follow even with batteries which are used a greater part of the time, to have them charged more often than their condition would appear to call for.

**206A. In case of faulty ignition with storage batteries, known to be in good condition, what would be the first thing to look for?** A loose terminal or terminals. Unless these are soldered or held mechanically, they are very apt to loosen.

**207A. Are there other terminal troubles met in ordinary use?** The terminals being of copper, which oxidizes easily, the copper salts or verdigris so formed, particularly on the positive terminal, stop the flow of current, being a non-conductor.

**208A. How is this removed?** By means of a strong solution of carbonate of soda, or ordinary washing soda. After having washed off all the formation with this, so the surface is bright and clean, coat with vaseline to protect from future similar formations.

**209A. What is the most common source of trouble in the ignition wiring?** A short circuit.

**210A. How is this caused?** In any one of several ways. The covering of the wiring

addition, an opening at the top, to which the atmosphere has access. The latter will press down the fluid so that it does not rise to any great height, and for this reason the fuel will not stand as high in the secondary nozzle as in the primary, thus requiring a much stronger suction to draw the fuel from it.

It is in effect a bypass, directly from the main body of gasoline to the vaporizing chamber, but so arranged that fuel will not be drawn from it except at high engine demands, which accompany high speeds or heavy working. In this way, no material change is made in the action of the vaporizer at slow speeds, but at high speeds a large additional supply of fuel, through a shorter and straighter passage, is provided. In this way, the extraordinary demands of high speeds are met very easily.

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**STRAINERS** form a very important part of the gasoline system, although many persons utilize these without knowing of it, because they are incorporated in the system. When this is not the case, and the need for them arises, it is a simple matter to incorporate one, while they retail at a very low price. In general, their greatest utility lies in separating water out from the fuel. When water gets into the gasoline, there is no way of detecting it until it reaches the vaporizer, where, of course, it does not vaporize, no gas is furnished the cylinders, and the motor commences to miss. It may be removed by pouring the fuel into the tank through a strainer of metal, but preferably through chamois, as this makes a more thorough job.

If this be not done, and the fuel is simply poured into the tank without taking any precautions, it is important to have a separator or strainer somewhere in the

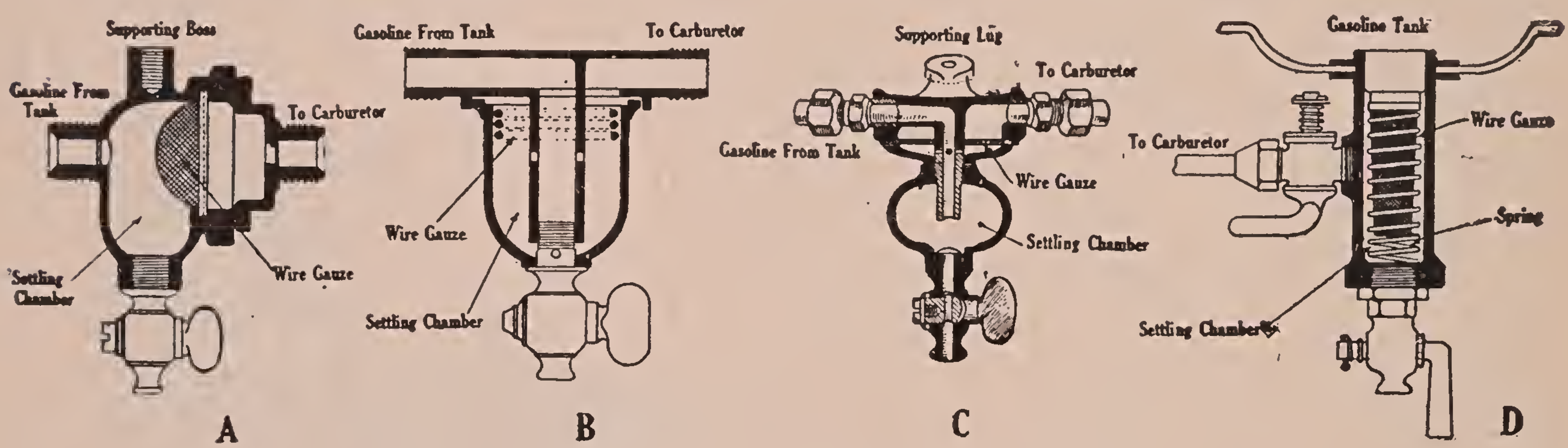


Fig. 91—Four different and efficient types of strainer.

system. In many cases, this is placed on the underside of the running board or at a similar low point on the car, the pipe from the tank being led down to the device at this point and back up to the carburetor level beyond it.

In those cases in which the strainer is separate, it assumes the form of a small casting, inside of which the fuel is forced to turn through two or more right-angled bends. In this way, the lighter water is thrown off at the bends, a special enlargement of settling chamber being provided there to catch this. The underside of this has a drain cock, so that the water may be drained off. In the cut, Fig. 91, four different forms of separate strainers are shown, although that

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may have been soaked through in several different ways, or the same may have been worn off by constant rubbing against some sharp edge. Where the insulation of the wires is not good, as on cheap wiring, another wire of a piece of metal may have dropped across from a metal part to a portion of this.

**211A. How could the wiring get soaked through enough to pass a current of electricity?** It is not necessary for it to do more than soak in, if the liquid is a conductor of electricity. Thus, with wiring located under the footboards, a leaking lubricator pipe, as the one from the oiler to the sightfeed will drip on the pipe and continue dripping after the insulation is soaked through, until a line of oil will reach from the soaked ignition cable to the frame or other metal part. Then, the motor will begin to miss, or stop, and the driver will wonder what is at fault.

**212A. Name another prolific cause of short circuiting due to liquids.** Every clutch throws a certain amount of oil. If the wiring is carried across the space below the footboards in a careless manner, without covering, this constant throwing will eventually reach the ignition cable and soak it, the same process outlined above being repeated. Similarly, with water, where it is used too freely.

shown at *B* is the most common one. The construction and action of all these is evident from the drawings.

When the separator is incorporated in the vaporizer, it has the form of a simple wire gauze set across the middle of the gas passage in the simpler instruments, or it has a circular form, as in the Pierce-Arrow, seen in Fig. 92. Here a double purpose is served, for a series of large holes allow of easy flow, while a finer, specially made fabric first separates out all water and foreign matter. The former might pass small bits of wood or anything like that, but the latter cannot. In addition to being readily drained, this has the advantage of being easily and quickly removed for cleaning or inspection. Sometimes when the strainer is not drained off as often as it should be, enough foreign matter collects to stop the flow of fuel.

In the DeDion-Bouton carburetor, the arrangement of the strainer is very simple, consisting of a hollow cylindrical shell with a flanged collar at one end. This is placed in the vaporizer with the upper end around the outlet pipe, the flange serving as a stop. As shown in Fig. 93, a spring around the whole metal gauze shell holds it up in place. The action is as follows: Gasoline enters through the pipe *A* to the fuel chamber. From there, in order to reach the float chamber, it must pass through the cylindrical gauze *l*, which serves as an effectual barrier for any water or foreign matters.

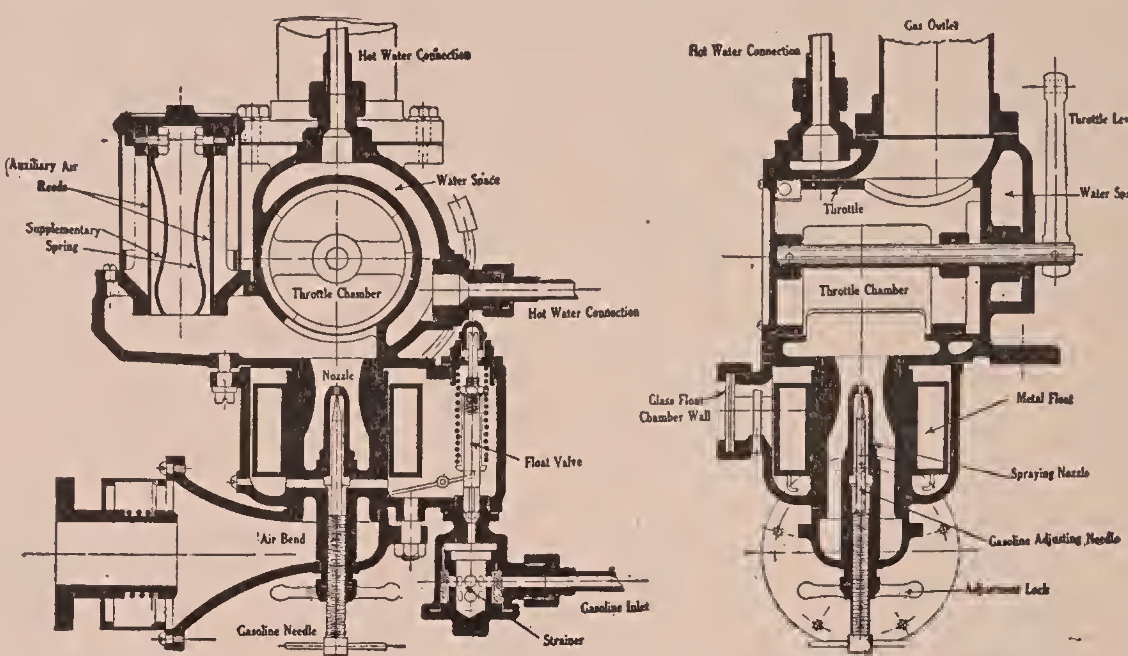

Fig. 92—Sectional drawing through the Pierce carburetor with Reed air valve.

The latter are as objectionable as water, for a very small piece of wood, paper, or other hard material may stick on the valve seat, thereby holding the valve open and preventing the engine from working properly, at the same time wasting the fuel. Erratic running of a motor is often caused by this. A small piece of wood or other material gets under the gasoline float valve, and holds it open until the carburetor floods. Then the engine speeds up, much fuel is drawn off, and the wood may be floated off the seat so that the carburetor works properly for a while. Then it gets back into the seat again, and the whole troublesome performance is repeated. These little annoyances make the strainer worth many times what it costs to get one and apply it. In the case of watered fuel, they serve, in addition, to point out the fact that the motorist is not getting what he is paying for.

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**213A. Is it possible to cause such a wiring short circuit when washing the car with a hose?** Yes. If the stream of water is turned on too strong, it may pass clear through the radiator, in through the air openings in the bonnet, or get in to the wiring in other ways and in sufficient quantities to soak through the insulation and cause a short circuit. This applies more particularly to the older cars, as on the more modern machines, the cables are carried in special conduits and protected in other ways from this very thing.

**214A. On an old car with a coil located on the dash, when the coil is suspected of causing trouble, how can this be determined accurately?** Borrow another coil, if possible of the same size and make from another owner of the same make and model of car. Take the suspected coil off and put the good one which has been borrowed, in its place, being careful of all wiring, all using great care not to cause any short circuits. Then, try running the engine with a coil which has given perfect satisfaction on another similar.

**215A. If it acts correctly, the engine fires correctly and regularly, and the old coil when put back in its place, again causes the old trouble and missing?** The inference is obvious that the old coil is at fault, and should be inspected by an expert. If, however, the old coil when replaced acts as good as did the borrowed one, it is a fair inference that the trouble lies elsewhere and is not in the coil.

When the various working parts of the carburetor are connected by means of levers, the operation of the vaporizer as a whole is effected materially. Thus, some makers connect the throttle with a lever which opens the needle valve and thus allows more fuel to flow as the former is opened, and closes off fuel when the throttle is closed in part or whole. The effect of this is to give an increased flow of gasoline when the throttle is pulled wide open, as when speeding, and just the reverse when slowing down and the throttle is closed. The former produces more rapid acceleration and greater speed, while the latter economizes on the fuel.

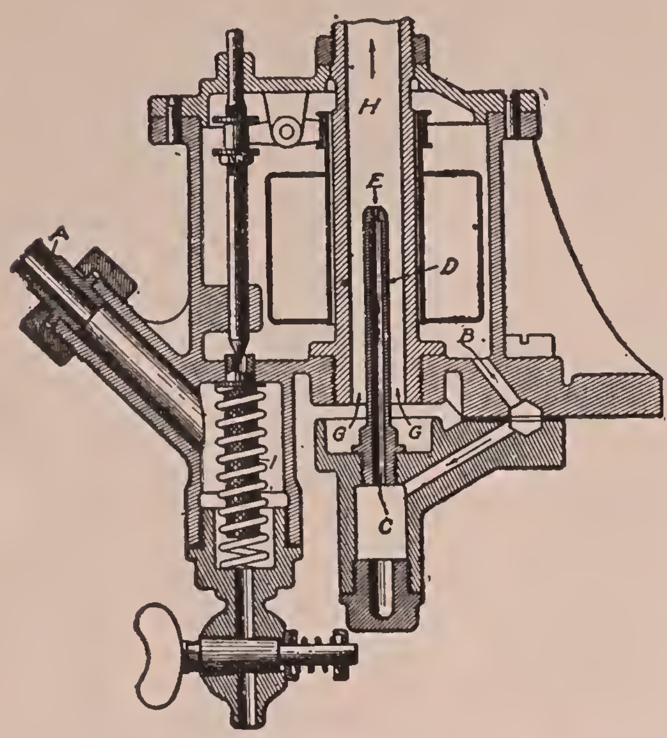

Fig. 93—The DeDion fuel inlet detail, showing the strainer arrangement.

In other cases, where the primary air opening is variable by means of a movable and hand-controlled member, this is interconnected with the throttle so that the amount of air entering at the primary opening varies with the variation in the throttle position, the speed of the motor of course varying with the latter. Another method of interconnection lies in joining the secondary air regulator with the throttle, so that the amount of air admitted at this point changes with the position of the throttle and the speed of the engine. In the operation of the modern carburetor, there are four variables: The throttle, the needle valve controlling the inflow of fuel, the primary air opening, and the secondary air inlet. It is possible to interconnect any two or more of these and get a different result from the same vaporizer with these parts not interconnected. Some designers favor one method, others the other. Each has its advantages and disadvantages.

**EASY STARTING** is made possible by having a bypass around the float chamber and in some cases around the vaporizing space as well. The idea of this is to introduce raw gasoline into the cylinders directly, so that a rich mixture which will insure immediate starting will always be formed therein. In the Stearns device, shown previously at Fig. 84, this consists of a connecting passage between the main body of fuel in the bottom of the float chamber and the primary vaporizing chamber. This normally is controlled by a pointed valve, spring seated; but for starting purposes this is pulled off its seat and fuel flows through regardless of the position of the float.

In the Stromberg this consists of an auxiliary nozzle, with its opening near the top of the mixing chamber and close to both the air inlet and the throttle outlet. In the Carter, it consists of a small and short inclined tube set into the vaporizer in such a way as to reach from below the ordinary vaporizing chamber with its multiple nozzles to the inlet pipe above the throttle valve. Its lower end is in such a position as to receive fuel on the very slowest turning of the engine shaft, while the position of its upper end above the throttle and independent of it is such as to insure a very raw gasoline being introduced into the cylinders.

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**216A. If a coil has been short circuited by water soaking into the interior, how can this be remedied?** If that is the only trouble it can be remedied by heating the coil gently near a fire, or as a woman would say, by baking it over a slow fire. Too much heat will melt the insulation and make it worse than before, in fact, render it practically useless. What is needed is just enough heat to drive out the water and to dry the entire interior in a thorough manner.

**217A. Do spark plugs give much ignition trouble?** Not as much as will the crude and inferior plugs of former times, but some.

**218A. What are the two or three principal troubles due to spark plugs?** Sooting, due to too copious lubrication as mentioned previously; breaking of the porcelain or mica insulation, and improper distance between the points of the spark plug.

**219A. How is broken porcelain caused?** The constant jarring of the car, passing over large stones in the road, or other severe bumps, screwing the plugs into the cylinder too tightly, as by the use of an 8 or 10-inch monkey wrench. Sometimes, too, there is a defect in the porcelain which such shocks bring out.

**220A. How can this be prevented?** Only by using care in the selection of the plugs in the first place, care in putting them in place in the second, and care in driving the car. Constant inspection is advisable. It

In the S G V carburetor, shown in Fig. 94, this is carried even farther, a small auxiliary pipe being carried from one side of the float chamber to the inlet pipe above the throttle. The lower end of this has a supplementary nozzle, while there is a small port for the admission of air midway of its length. This is so proportioned as to deliver but a small amount of air, the result being a very rich mixture. The pipe may be seen in both views of the device, while an enlarged sketch of the supplementary jet and the lower end of the tube will be found at the left side.

**SPRAY NOZZLE SHAPES** have considerable influence upon the results, according to the different designers; consequently, we find a considerable number of different shapes in common use. Not all of these can be shown and described; in fact, it would serve no useful purpose to do so. In Fig. 95, four of the principal ones are seen, these being designated as *A, B, C* and *D*. The first consists of a plain circular passage reduced in diameter toward the top, where a hole is cut through which varies in size from the bottom upward. The effect of the combination, then, is two sections of cones joined together so as to diverge toward and away from the smallest point. The effect of this is to throw the spray out in a gradually enlarging and widening stream. This form needs no needle valve, and is not adjustable, except as the nozzle may be taken out and the hole drilled larger or replaced with another having a smaller opening. It is the most popular form, as will be noted by looking back over the following carburetors described herein which have it: Stromberg, Fig. 77; Peerless, 78; Stearns, 84; Daimler, 88; Zenith, 89; DeDion, 93, and S G V, 94; while G & A, Fig. 76, is a slight modification of this in that it has a straight hole and a straight outer end.

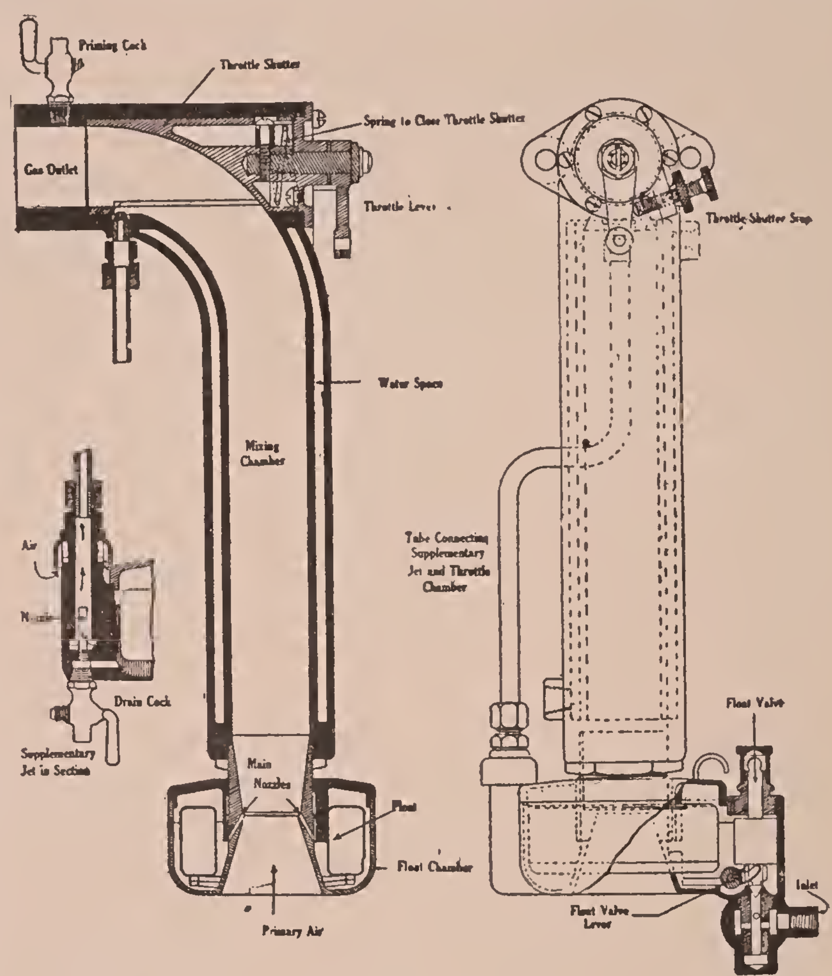

Fig. 94—How the S G V carburetor is arranged with an auxiliary jet.

When a movable valve is set into the inside of this so that it seats on the lower part of the smallest part of the opening, the form *B* is made. This has a double effect; it makes the opening variable at will by screwing the valve up or down, thus decreasing or increasing the amount of liquid which can pass, and, in addition, it changes the form of the spray. The latter is brought about by taking out the center of the hole, so to speak, this being occupied by the point of the needle valve. In addition, the sides of the valve cause the fluid to spread out more in escaping past it, so that a wider spray is formed. This form is easily

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is possible to run along the line of eight plugs (two per cylinder with a four-cylinder engine), and give each one a light sideways movement in less time than it takes to tell it. If all plugs are right none of them will move. If any move, even slightly, they should be inspected with care.

**221A. Is mica as easily broken as porcelain?** No, it is not and many motorists make a practice of selecting all mica plugs for this reason. In general, porcelain is considered a better insulator, but the mica is sufficiently good so that no difference can be noted.

**222A. What other members of the ignition system are likely to cause trouble?** The breaker box of the magneto if the car has magneto ignition, or what corresponds to it in a battery system, the distributor.

**223A. How do these cause trouble?** Where the ring of each is normally insulated except at the four (or six) points where a contact is desired, some liquid gets in and causes a short circuit.

**224A. What is the most usual form of this?** Water may get in but the usual trouble is due to too copious lubrication. A distributor, timer, breaker box or other similar part needs only a drop of oil about every 300 miles. Some instruments are built to use even less than this.

**225A. How can fuel consumption be improved usually?** By providing additional

second in popularity, if not actually first, when the very lowest priced instruments are eliminated. It is used on these makes which have been illustrated and described previously: Fig. 81; Saurer, Fig. 85, and Pierce-Arrow, Fig. 92.

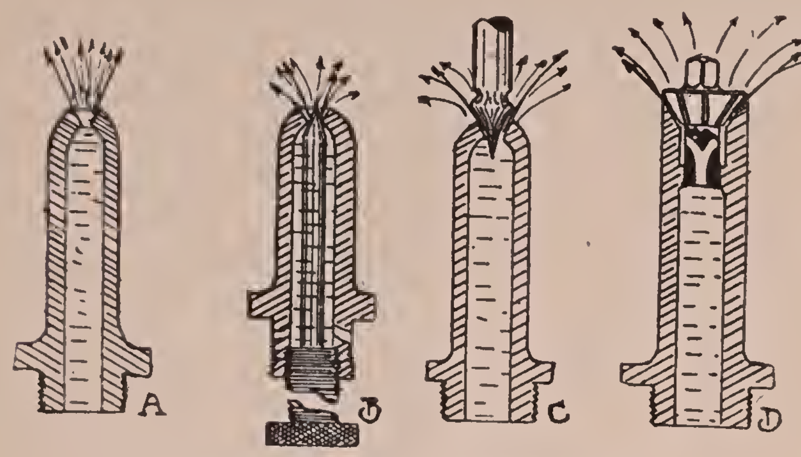

Fig. 95—Four of the common types of spray nozzles now generally used.

If the needle valve be turned upside down and screwed down on the opening from above, its point being hollowed out in addition, the form of *C* is made. This extra hollowing out and the position of the needle above where it deflects some of the spray outward causes the further enlargement of the stream as compared with *B*. This form is used by many makers, including: Holley, Fig. 80, and Kingston, Fig. 82.

When the sides of the needle are grooved and this set down into the top of the nozzle, it forms type *D*. This is non-adjustable, but has as many openings as there are grooves in the tapered portion, usually six or eight. As these may be made very small, the result is a finely divided and well-distributed spray. No carburetor with this form has been shown, but the Longuemare (Fig. 79) is a modification of this, the difference lying in the holes being turned horizontally while the inner passage has a spray needle on the order of *B*.

**AIR VALVES** have a number of different forms and shapes, varying arrangements of spring and adjustment, also differ in nature and method of operation. In the flat valve type, we find them arranged vertically with the valve working both upward and downward, horizontally and inclined. Then, there is the cone seat, which is found in all the same variations, the flat reed working both horizontally and vertically (as in the Pierce-Arrow, Fig. 92), the balls working vertically only the swinging disc and the rotating piston. Each one of these has its advantages which, in the opinion of the designer, make it preferable to all the others.

**INLET PIPE SHAPES** vary widely, practically every different make of motor having a form widely different from all the others. Of late years the shape, length, number of bends, and other details of inlet pipes have been given much attention, in order to reduce the gas friction to a minimum and to supply a perfectly even and regular mixture to all cylinders. Formerly, when this was not the case, a number of firms used a form of pipe in which all cylinders drew from a single long manifold with the carburetor at one end. The result of this arrangement was practically to starve the cylinder at the far end, the other three sucking out all the gas formed as fast as the carburetor could furnish it. In general, four-cylinder motors now have a two-branched pipe and six-cylinder engines a three-branched shape, thus equalizing the distance from the carburetor to each one of the cylinders.

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air to the intake system. In general, carburetors do not give sufficient air, in fact many of them can not be set to give all around satisfaction and still furnish the fuel mixture with sufficient air.

**226A. In what way can this be done?** Some kind of an air valve can be built into the inlet pipe above the carburetor, with a lever or wire to the driver's compartment to allow of his pulling it into use or throwing it out, as he considers the running of the car shows a need.

**227A. In what other manner may fuel consumption be lowered?** In a number of older makes of cars, the size, shape and arrangement of the vaporizing space is such that much fuel is drawn in which is not vaporized. This can be remedied by the introduction of a small spiral, helix or rotating wheel which will beat up the fuel particles into a smaller size. This enables quicker and more thorough vaporization. Somewhat the same result may be obtained by the introduction of one or more fine brass gauze screens across the interior of the inlet pipe. Any of these schemes will have an effect on the fuel consumption.

**228A. When an engine refuses to start, and the only clue to trouble is that the car has just been washed, what would be suspected?** Probably some water has gotten into the carburetor, either directly or through the air valve.

**229A. How can this be remedied?** If there is no other simpler way available, draw off what fuel is in the carburetor. Then let fresh flow in, and the engine usually will start on the first or second turn.

# CHAPTER VI.

# Lubrication and Cooling.

NEXT to having a car and the required parts to make it run, as proper carburetion and ignition systems, etc., the most important thing is to have it lubricated properly so that it will continue to run indefinitely. To many persons the instructions given by the makers of cars to oil this part once a week, grease that every 500 miles and so forth, are more or less attempts on the part of the maker to tell the user how he must use the car and in part constitutes one of his tricks to protect his own interests. Such is far from the actual case; the manufacturer's responsibility ceases as soon as the sale is made and the car delivered; he tells its owner how and when to lubricate solely for the latter's protection.

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**LUBRICATING.** When any part rotates or slides within or in contact with another, friction is set up. In time, this will wear out the softer of the two parts, and it will have to be replaced with another, when the wearing process will start over. A lubricant placed between the two surfaces reduces the amount of friction and wear, in an amount which varies with the thoroughness of the process and the quality of the lubricant, together with its suitability to the works. Friction consumes power, and since this power does no useful work, it is wasted. In a case, like that of the automobile engine, in which the maximum power output is a fixed quantity which cannot be increased, all friction which is set up wastes a certain portion of that power, making so much less available for speed, carrying capacity or hill climbing. The inverse of this is equally true if friction be eliminated as much as possible through perfect or nearly perfect lubrication; there will be more power available for speed and similar purposes.

The purpose of lubrication on the motor car, then, is twofold: First, to reduce friction to a minimum and thus give the maximum amount of power for propelling the car and its load; second, to reduce wear to a minimum and thus cause the parts to last for a greater length of time, reducing the cost of maintenance. From this it is apparent that everyone who deliberately neglects the lubrication of his car or its parts is no one's enemy but his own, and that he will pay for all such neglect in greater fuel bills, slower speed, less power, and greater and more frequent repair bills, to say nothing of losing the use of the car when it is being repaired or having a part replaced by a new one.

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### How to Remedy the Most Common Automobile Troubles

**240. What is lubrication, and what is its purpose?** Lubrication is a method of keeping two metal parts, one of which rotates or slides within the other, from actually touching one another while the rotation or sliding is going on. This is done by means of oily, greasy or unctuous substances which form a minute protective film between the two surfaces.

**241. If this film of lubricant be absent, broken or interrupted, what happens?** The rubbing of the metals one on the other heats them, they expand until the inner one seizes upon the outer, when no further sliding or rotation is possible.

**242. Does this always happen?** No; in some cases one metal is much softer than the other. In that case, the softer one is cut away or worn.

**243. How does this result?** In a short time, the softer metal is cut away so badly that the one which rotates or slides is not guided properly, and thrashes around. This may do nothing but make a noise, or it may be vital to the action that the motion be continued in a straight line, in which case me-

**FOUR LUBRICATING GROUPS.**

Considering the car as a whole, there are four main groups to be taken into account in the lubricating scheme. These are: The engine and its parts and accessories; the transmission complete; the rear axle and differential gear, including the driving shaft; the chassis parts not included in these, notably all operating lever parts, etc. In a few rare cases, the transmission is placed on the rear axle, so that Groups Two and Three become one; but as these cases are so rare, the four will be considered as outlined.

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**OILING THE ENGINE.**

Naturally the engine is the most important part, and, as such, receives the greatest amount of lubricating care. In this there are two general methods for the interior parts, the exterior parts being taken care of by grease cups and oil cups conveniently located, and to be mentioned later. The two interior lubricating methods are called the splash system and the pressure system, from the methods of applying the oil. There is, it is true, a combination of the two—in fact, practically all of the pressure feed systems use some splash. In the splash system, the lower part of the crankcase is so made as to have a series of pockets beneath the lower ends of the rotating connecting rods, into which the latter dip for some distance. When oil is poured into the crankcase in sufficient quantity, it rises in these pockets to a higher level than the lowest point of the rotating rod end. This results in the rod dipping into the oil at each turn. A scoop or small pipe is placed on the end of the rod in such a way that its open or receiving end is toward the oil—that is, is presented to it first. In this way, oil is taken up at every turn. When the rod lifts somewhat higher, this flows down to the bearing; in this it is aided greatly by the inertia of the stationary oil, which tends to force the oil inward or to the bearing. Between the two a considerable amount gets to the bearings of the connecting rod.

From this the crankshaft is drilled with interior holes to lead the surplus oil to the main or stationary bearings, where other radial holes lead it outward. Such is the pressure exerted by the two forces, when the engine is running at high speeds—say, 2,000 revolutions a minute—that a considerable amount reaches these bearings in some cases too much. In addition, the connecting rod has a central drilled hole or an oil pipe which leads a portion of the surplus up to the piston, whence it flows out through the hollow piston pin to the cylinder walls, thus lubricating them.

Entire dependence is not placed upon this method of lubricating the walls, for the rod ends in striking the surface of the oil in the crankcase splash up a great deal of oil, which in the form of a mist fills the entire open space in the case and the lower ends of all cylinders. When this mist falls on the lower parts of the cylinder walls, it is picked up by the pistons at each stroke and carried up to the higher parts, thus lubricating practically the whole surface of the cylinders.

One objection which has been raised against this method is that it is wasteful of oil; a considerable amount must be placed in the crankcase to start with, and a minimum level maintained, else the parts will not be lubricated at all. Again, on a down grade, if the interior of the case forms but one well, the oil all

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chanical trouble results as soon as one part is worn.

**244. Suppose a piston stick in a cylinder and stops the engine?** The cause is a lack of lubricant, as pointed out above.

**245. How may this be remedied?** It depends upon the seriousness of the case; if the piston is badly stuck, it should be allowed to cool a little, then kerosene or other thin lubricant poured upon it in quantities. When this has had time to soak down between the two metal walls in contact, it is possible that the two may be separated by rotating the engine by hand.

**246. What should be done to prevent a repetition of this?** The old reservoir should be examined, the oil pump and its drive looked over for defects or breaks, all pipes should be inspected, and finally the lubricant itself examined.

**247. What could be the matter with the oil that would cause this trouble?** It might be full of dirt, sand or other foreign matter which was not noticeable when pouring in the fairly thick liquid, but which soon cut the cylinder walls when introduced there. Further, the oil might be so thick or so thin for the work it had to do as to be entirely unsuitable. Thus it would be possible to use an oil so thick that it would not pass between the cylinder walls and the piston. Or an unusually light, thin oil might have been used which did not have sufficient body or enough lubricating quality to be suitable for this severe work.

flows to the front so that the forward cylinders get an excess and the rear ones get none. On an up grade, the reverse happens: All the oil flows to the rear end of the case, the result being that the rear cylinders get too much and the front ones are starved. This objection has been met by making the case in such a way that the rods dip into small individual troughs, so that no matter what the grade, each one has its supply of oil.

Another objection is that the motor does not get a great deal of oil when pulling hard at comparatively slow speeds, as in heavy going or on steep hills, because the splash method depends upon the motor speed to deliver the oil and at slow speeds it would produce small amounts. This also has been met by making the individual troughs movable and connecting them to the throttle or foot accelerator. When the latter is opened wide, the troughs are brought up close to the rods, with the result that they dip deeper and splash more. It is a refinement, however, which is found only on the more expensive motors.

**IN THE PRESSURE SYSTEM,** the oil may be pumped directly to the bearings, and then through internal oil holes to the connecting rod bearings, and from there up the rod to the piston pin and cylinders. In addition, other leads go to the cylinder walls directly, as well as to the timing gears, the water pump and other accessories. In Fig. 96, some of the methods in use are shown. At *A,* the splash system is seen, in which the bottom of the case forms a deep well, but a lighter partition above it forms troughs for the individual rods. The scoop is plainly seen. The form at *B* has a

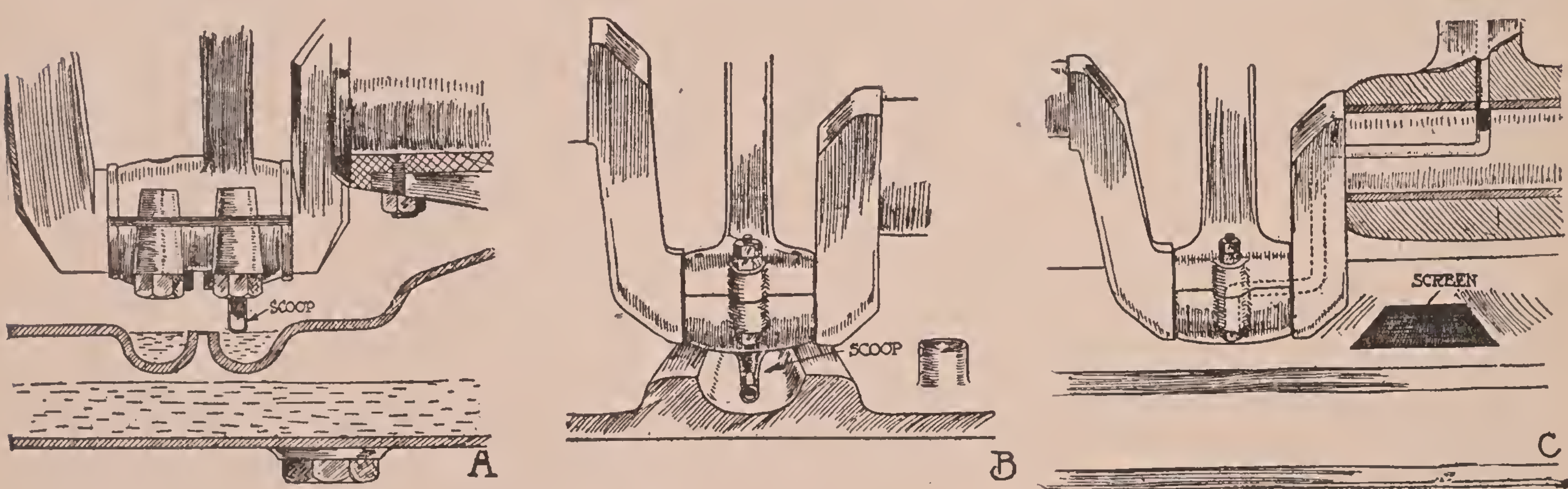


Fig. 96.—The Three Forms of Oil Scoops Used in Motor Lubrication Systems, and the Way in Which They Operate.

double crankcase, the individual troughs being formed in this while an overflow carries the excess down to the well below. This form requires a pump to keep the troughs filled; at *C* one sees a pressure system without splash, the drilling through the shaft and rod being quite plain. When there is an excess of oil to either the main or connecting-rod bearings, this drips down into the lower part of the case, where it filters through the screen shown and reaches the well below, whence the pump draws its supply.

**248. Does this apply to other parts beside cylinders?** Yes; practically all important rotating or sliding parts of the engine and transmission of modern cars are made with a running clearance of less than 3/1000 of an inch, and a great many of them with less than 2/1000. Into this extremely small space, divided by two if it be a round shaft in a round hole, the lubricant must be forced, and there it must do its work.

**249. What is this work?** It must prevent wear where one metal is softer than another, and reduce friction. The former reduces repair expense, the latter makes the car run better and faster on the same amount of fuel and oil. Both make for cheaper motoring.

**250. In general, is engine lubrication the same as that for transmissions and other parts?** No; practically every separate group has its own form of lubrication and kind of lubricant. These are determined by the amount and character of the work it does, the nature of the workmanship and the fineness of the fit, and its exposure to the elements which might wash or carry away the lubricant provided.

**251. Suppose an oil hole becomes stopped up?** It should be cleaned out as soon as discovered, care being taken not to get any of the dirt into the bearing. In such a case, an extra amount of oil is advisable in order to make up for a possible previous lack while the hole was stopped up.

**252. What about other points where no oil hole, grease cup, or other provision has been made?** They should be lubricated just the same. Wherever there is a rotating, sliding or moving part, it should have some kind

**ANOTHER SYSTEM, USING PRESSURE,** is the so-called gravity form, in which a large tank is placed high up on the cylinders or other part of the motor, the various leads proceeding from this. It is kept filled by a pump, this doing nothing but draw oil from the well in the bottom of the case and force it to the tank. From the tank the pressure of gravity is used to circulate the lubricant. This form, as shown in Fig. 97, has the great advantage that in case of accident to the pump, such as a shaft shearing off, or the passage from the well clogging up, the tank full will continue to feed oil to the various bearings, and, since this is very large, the motor would run a good many hundred miles with the pump out of commission. It has a filling plug on the top, so that when the gauge glass on the dash showed the driver that the pump was not working, more oil could be put into the tank and the pump neglected for the time being. This location of the filling plug is a much more convenient one than when placed lower down on the crankcase.

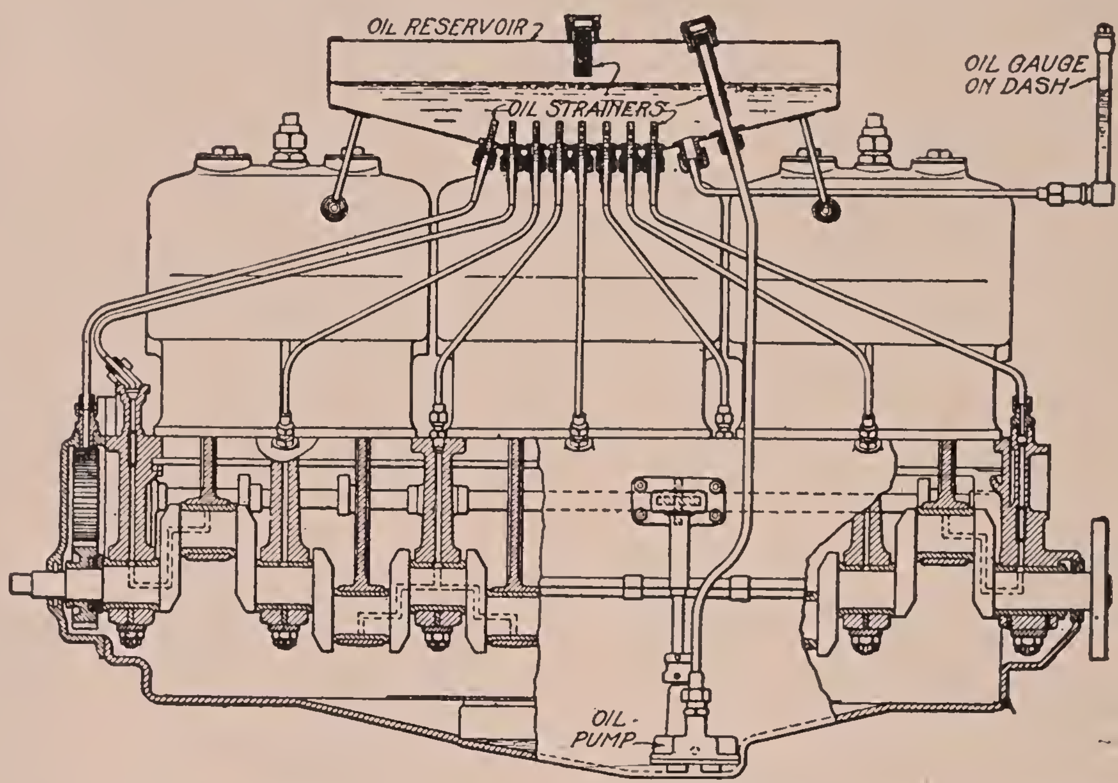

Fig. 97.—An Oiling System, in Which the Tank Placed on the Cylinders Feeds all Bearings by Gravity, Being Kept Filled by a Pump.

A slight variation from the previously mentioned pump system lies in the use of a pump for every lead—that is, for 10 bearings to be oiled, 10 pumps. These are enclosed in a large case, are driven off a single shaft, have their own oil well whence they draw their supplies, and consequently have the filling plug for the whole system. This form is called a mechanical lubricator, and generally has a telltale on top for each lead. If, then, any one part is supposed to be getting less than its share of oil, the telltale would show this to be true or otherwise. Such a lubricator generally is placed under the hood, very close to the motor, so as to drive off one of the accessory driving shafts, and also so as to make the numerous oil pipes as short as possible. Such a system has many points to recommend, as the pumps may be set to deliver a large quantity at first when the motor is new and stiff, and consequently needs plenty, while later this quantity can be reduced for economy's sake. Fig. 98 presents a view of an oiler of this type with four leads for that number of bearings. The oil gauge glass at the corner will be noted, the filling cap on top, the supply pipe from the crankcase by means of which the used oil, after filtering, is returned to the oiler so as to be used over again, and the method of driving the lubricator from the accessory shaft.

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of a lubricant, administered at suitable intervals.

**253. Driving late in the fall when the temperature gets low, the motor acts sluggish?** The cold weather has thickened the oil to a point where it is not as suitable as it should be. Draw all of it off and refill with a lighter grade having a much lower freezing point. Ordinary good summer oil will have a cold test of 30 degrees or higher, but winter oils should have a cold test of 20 degrees or lower.

**254. Which oils contain the most carbon?** It is difficult to say; in general, dark oils have more carbon, but this is not always the case.

**255. Can this be filtered out?** In manufacturing, yes; but by the ordinary user, no. It is wise, however, to filter all oils not obtained in sealed cans. This may be done by running it through cheesecloth or fine mesh wire cloth, or both, before using. With heavy oils this is more or less of a long, dirty job, but the superior results make it well worth while.

**256. What is the general division of lubricants for the various car units?** Oil for the motor, heavy oils or grease for the transmission, grease for everything else.

**257. Is this a firm rule, always observed?** Not at all; it is simply a rough statement. Many use heavy oil for the motor, many

The grease cups for the water pump can be seen, the additional one for the rear bearing of the front end of the shaft, the oil cups on top of the motor for the rocket arms of the valve system, and others. It is by means of this kind that the exterior bearings of the motor are lubricated.

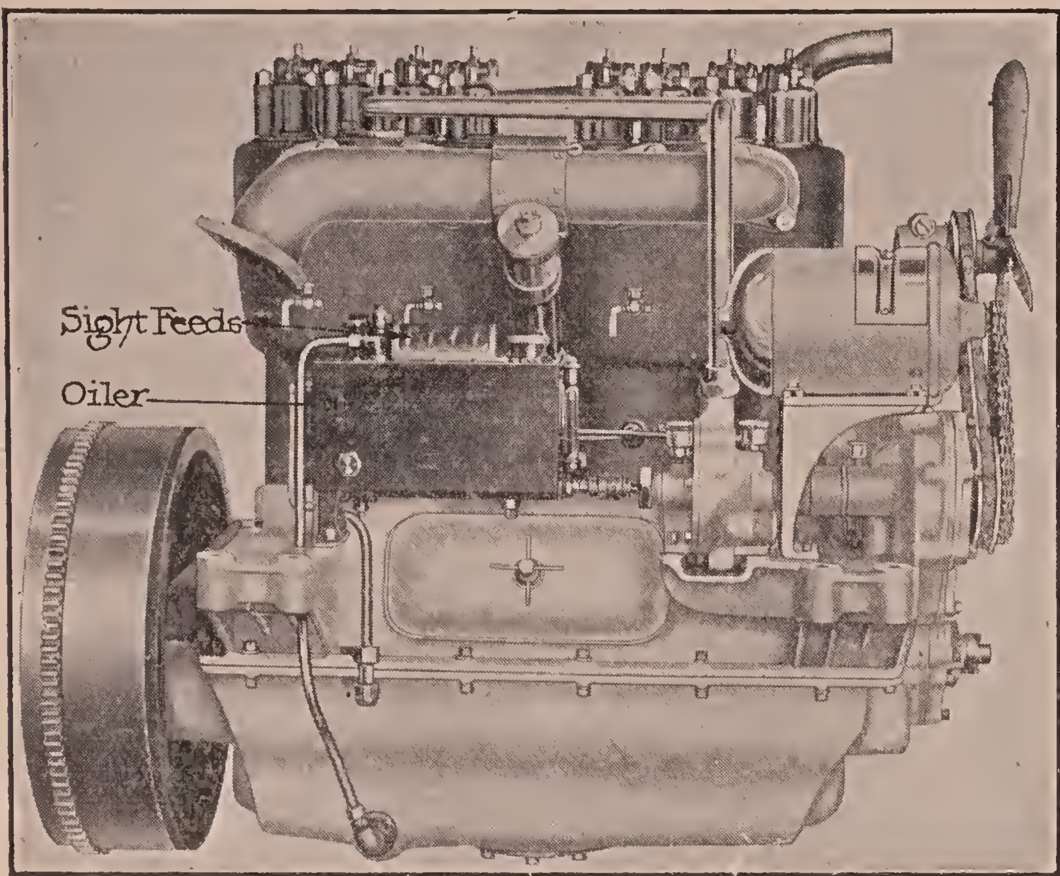


Fig. 98.—An Oiling System, in Which a Mechanical Lubricator with Four Feeds Forms the Basis. This is Positively Driven from the Magneto Shaft.

A section through the crankcase of a motor, with which is combined both the clutch and transmission—that is, a unit power plant—is seen in Fig. 99, and an end view of the same at Fig. 100. The former shows how a pool of oil is maintained in the rear end of the crankcase, into which the flywheel dips, the rotation of this being used to circulate the same. By means of this, it is thrown onto the silent chain which drives the camshaft and also into the gear compartment. In the latter the gears themselves

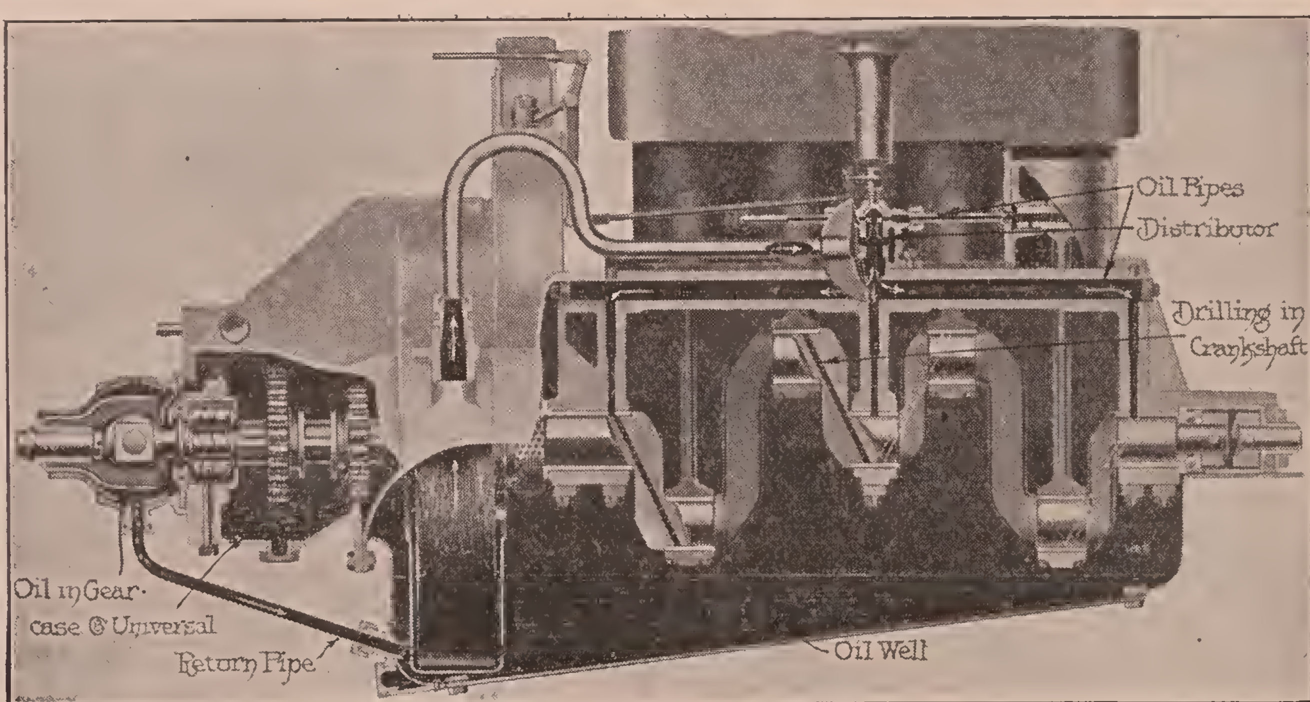


Fig. 99.—Side View of a Successful System of Lubrication in Which the Flywheel Really Circulates the Oil, Forcing It Into Various Pipes, Which Lead to the Different Bearings and Parts to Be Oiled.

agitate the oil and keep all parts well lubricated, the oil being forced over into the universal joint from the casing of which a pipe returns the excess to the well.

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others add graphite to the oils used. A number of engine parts, as fan shaft, pump shaft and others, are lubricated with grease. Not all transmissions are greased. Many prefer a graphite grease, still others like a heavy oil, some of the most successful use a light oil and grease combination, while others oil the bearings and grease the gears. For the rear axle, there is an equal divergence of opinion; some want oil, others heavy oil, some grease alone, others heavy oil and grease. It is the same way with other parts; different makers call for a different lubricant. The general rule given above, however, holds to a surprising percentage of all the cars.

**258. What happens if the oil or grease is omitted from the interior of the transmission?** In this case, the lubricant is not utilized so much to prevent friction, as to silence the noise of the gears meshing with one another, and the other noise due to shifting them into and out of mesh constantly. Of course, the lubricant used does act in the ordinary manner for the transmission bearings and shafts, but the filling of the gearcase is done for the purpose of obtaining silence. The answer to the question, then, is the omission of this would make the center part of the car very noisy.

For the main parts of the motor, a distributor (shown more plainly in the end view) takes the oil at the engine end of a large-sized tube, and then forces it through a special passage bored in the crankcase for this purpose. Off from this, there are other passages which lead the oil down to the shaft bearings, whence internal drilling, same as that previously described, leads it down to the connecting rods. The same distributor delivers oil in a constant stream to the cylinders, by means of a passage bored between each pair, this supplying both. On the bearings for the camshaft, a form of shelf catches a quantity of the oil inside the case and holds it, thus forming a source of supply for the bearings of the camshaft. By examining these two figures in detail, an excellent idea of the lubricating system of this 1914 car will be gained. For one thing, particular attention is called to the filling cap and throttle for this system shown in the end view. The latter is connected up to the throttle lever in such a way that at high speeds a considerable stream of oil is turned into the cylinders and a larger amount than usual into the main bearings, while at slow rates of travel both are cut down somewhat. This makes for efficiency and economy.

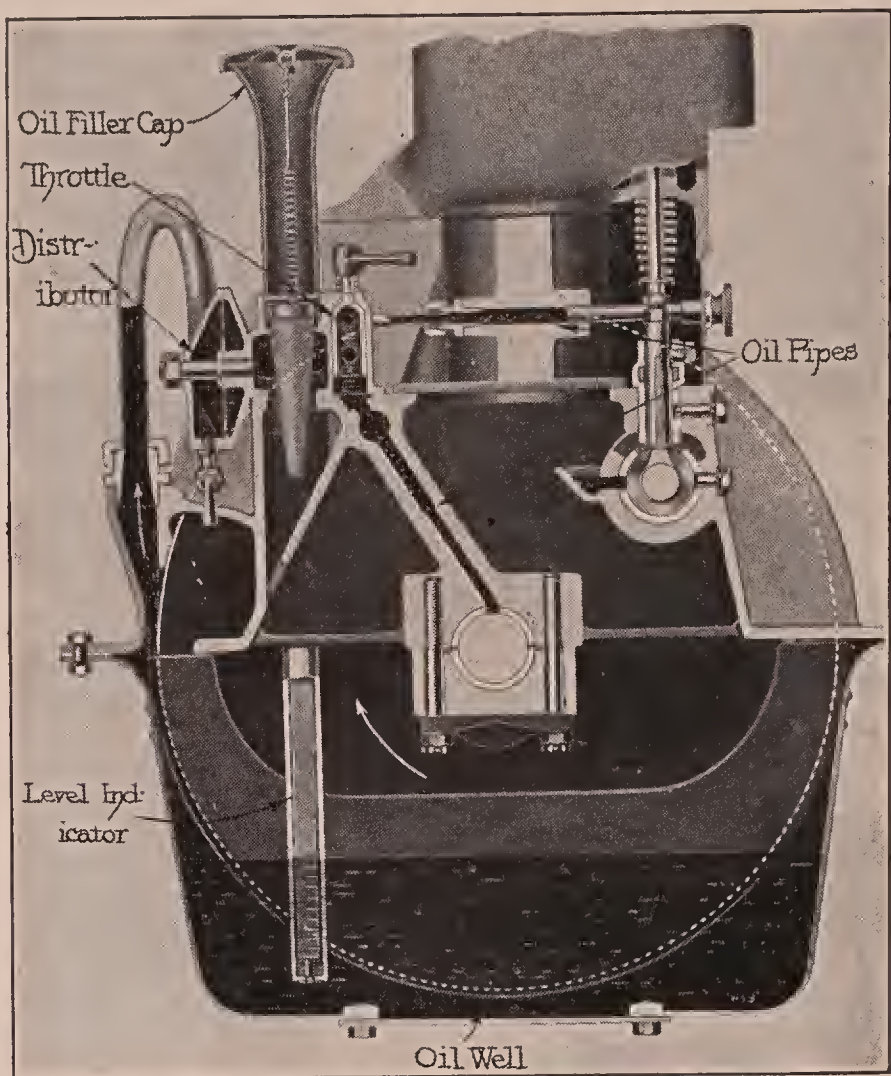

Fig. 100.—End View of the System Shown in Fig. 99, Showing the Distributor and Throttle, Unique Features of This Arrangement.

A somewhat similar system, yet differing widely in details, for it applies only to the motor, the clutch and transmission being separate units, is that shown in Fig. 101. This is a force-feed circulating system, in which a single pump located at the bottom of the case takes its supply therefrom, pumps it through a tube to the center of each of the main bearings of the hollow crankshaft, whence it reaches all bearings, connecting rods, piston pins, and piston. In addition, a separate lead supplies the timing gears at the front of the motor, while a bypass to a gauge on the dash shows the operator the workings of the system. Filler and level indicator may be seen as well.

In this, the drilling of the crankshaft and the methods of plugging the openings where the drills enter will be noted, as the drawing makes this point especially clear. This is a complicated job, requiring much individual skill as well as special apparatus designed for this particular purpose.

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**259. Would anything else happen if it were omitted?** To a certain extent, it prevents grinding, chipping, and cutting of the gears. Were it omitted, this action of the dry metal gear faces one on the other would be very great, and probably would wear out the gears in a surprisingly short time, necessitating their renewal.

**260. What good is graphite and how does it improve lubrication?** Graphite seems to have a glazing action on any metal part to the surface of which it is applied as a lubricant. To a certain extent, even the most finely finished parts have a rough surface, and the graphite seems to fill in these rough places and stay there, so that it renders the surfaces on which it is used perfectly and permanently smooth. This gives superior lubrication action, for, after the graphite has made the surface of the shaft or other part perfectly smooth, it runs with less friction. As a consequence, lessened oil consumption is claimed for it.

**261. When used with oils, as for cylinders, how is it put in?** A tablespoonful of the finest grade obtainable is added to each quart of cylinder oil, this being utilized in the usual manner. After the graphite has been used for a short time, it is claimed that the flow of oil may be reduced very materially. Also, after the engine is well "loaded" with the graphite, the amount of this may be reduced to two tablespoonfuls to the gallon. All this has reference to cylinder use; for other purposes, other grades and different proportions are used.

**OILING TRANSMISSION.** Usually the transmission is lubricated by occasional fillings of its case, by hand, with a fairly heavy grease, graphite, or oil, or combinations of these. The quantity put in depends upon the size of the case and its capacity. There are special transmission lubricants, and many makers go further and have a lubricant different from anything else on the market put up for especial use in their transmissions. It is doubtful if this is necessary, for they are the same kind of gears, consequently they have the same requirements. In general, when a transmission has been fixed properly, as outlined above, and to the maker's exact directions, this should be good for a month's or a thousand miles' running. At the end of that time, the case should be drained as far as possible, the balance flushed out with kerosene, and a new filling of lubricant, new and fresh, put in. The same general proceeding applies to the differential housing with the gears within. If this is combined with the transmission, it makes but one such dirty job, but when the two are separate units, there will be two such jobs.

This is well worth doing, and is advocated for the motorist's sake and not as a matter of theory. A considerable quantity of dirt gets into the transmission case, not a little metal is worn off the gears in grinding one against the other for 1,000 miles, and in the numerous shifting done in that distance. These particles get into the lubricant, and by it are carried in between the teeth of the gears and thus are ground into their surfaces, or are carried into the bearings and may do damage there. By draining off the old stuff after each 1,000 miles run, it is possible to keep these minor wearing quantities down to a minimum, while at the same time washing out with the kerosene carries off all the small particles present, and gives the driver a good opportunity to examine the various gears.

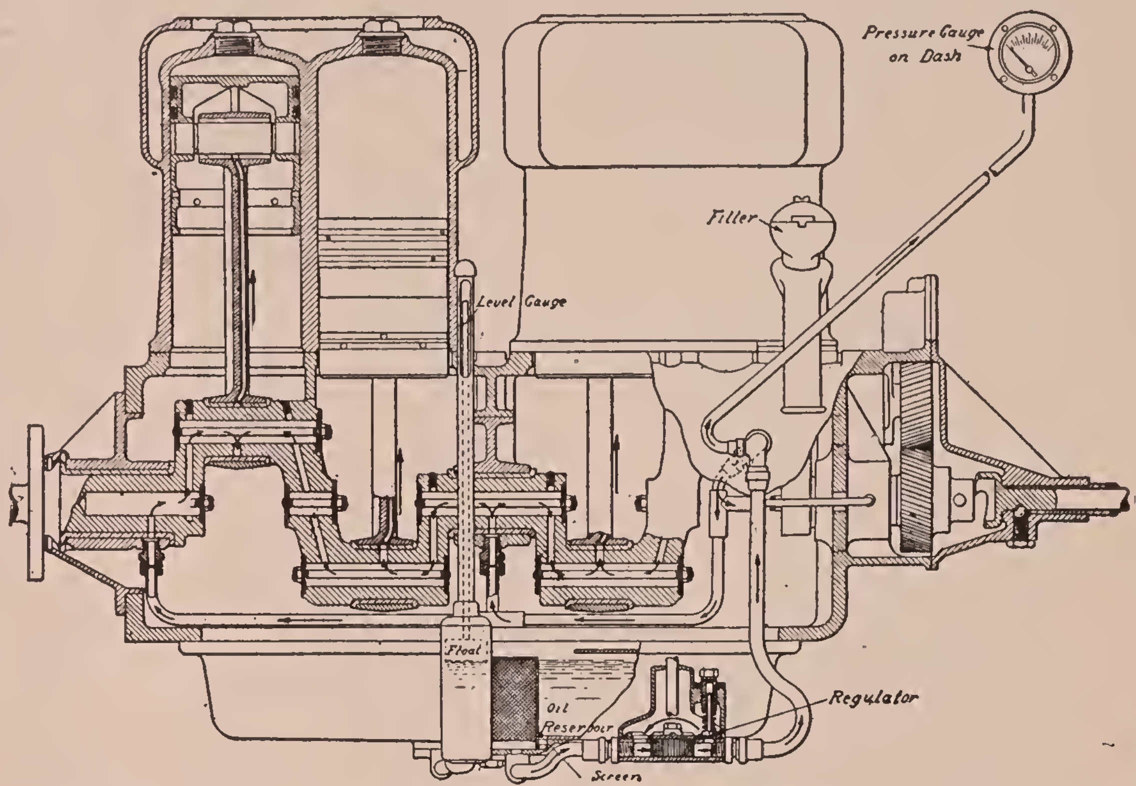

Fig. 101—A Well-Known Force-Feed System, in Which a Pump Forces the Lubricant Through Hollow Pipes to the Crankshaft, Drilled Out for This Purpose.

This same draining and cleaning process should be applied to the engine crankcase, to the timing gear case, to the front wheel bearings, and to the universal joints. The interval—1,000 miles, or a month's running—is about right for these, although the lubricant might vary. Thus, while the transmission and differential contained mostly grease, the universal joints might be filled with

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**262. In the absence of any set rule for transmission, how would the driver lubricate this?** Make a mixture of the oil for use for the motor and a good grade of cup grease, using half of each.

**263. How is the clutch lubricated?** Its surface should never be lubricated with any kind of ordinary lubricant. The leather may be softened if it gets hard or stiff, however, with a little Neatsfoot oil, which is more of a leather dressing than a lubricant. The clutch operating parts should have a heavy oil applied about once in each 400 miles or every two months.

**264. In case oil does get on the clutch so that it slips continuously, what can be done?** If this is not noticed until the driver gets out into the country, some very fine powder, as the talcum for inner tubes, may be thrown in on its surface. Lacking that, fine sand or dirt from the roadside is better than a slipping clutch. If the latter be used, as soon as it is feasible to do so, the driver should get some kerosene and wash the clutch out thoroughly with it. If he has kerosene with him on the road, when the slipping is noticed a little gasoline may be poured onto the surface and allowed to work all around it. This mixes with and dilutes the oil. Then the whole may be washed off with the kerosene. A good plan is to wash the diluted oil out with water, if a hose be handy, and then use the kerosene later to clean off the water and the last traces of the oil or gasoline.

graphite grease, the crankcase with the lightest of cylinder oils, and the timing gear case with a slightly heavier oil. In all cases, clean out all lubricant, use kerosene to flush, and then refill.

Many persons say that this used oil cannot be used again, but such is not the case. By saving the lighter oils separate from the heavier ones, and filtering each kind carefully and separately, they can be used again by mixing with the next heavier form for different parts of the car which require a heavier lubricant. In doing this, not less than half new lubricant should be used. When it comes to the heaviest form, that can only be used again with grease, while drawn-off grease cannot be used again. Generally speaking, this is not good economy, for, although good oil is more expensive, using over a dirty lot of it which would ruin a bearing or two simply for the sake of saving 10 cents' worth of lubricant is poor economy.

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**OILING AXLES.** Of the various grease and oil cups on the axles, the driver should have a regular routine for these, and go over them in order, filling each grease or oil cup as soon as it becomes empty. Taking up the rear axle first, Fig. 102 shows a truck rear axle and countershaft, the former answering equally well for the rear axle, and the whole group for trucks and chain-driven cars. On this, the arrow marked *A* points to the large grease cup which forces grease to the main bearings of the wheels. Twice a month, or every 500 or 600 miles, these wheel bearings should be smeared with grease, in addition to which the cup will supply all needs. It should have part of a turn each time before going out. The small oiler at *B* is for the bearing of the brake cam lever at that point, its size indicating its relative importance. It should have a drop of oil every 300 or 400 miles. The slightly larger cup at the frame bearing for the brake operating rod should have the same treatment, with two drops instead of one.

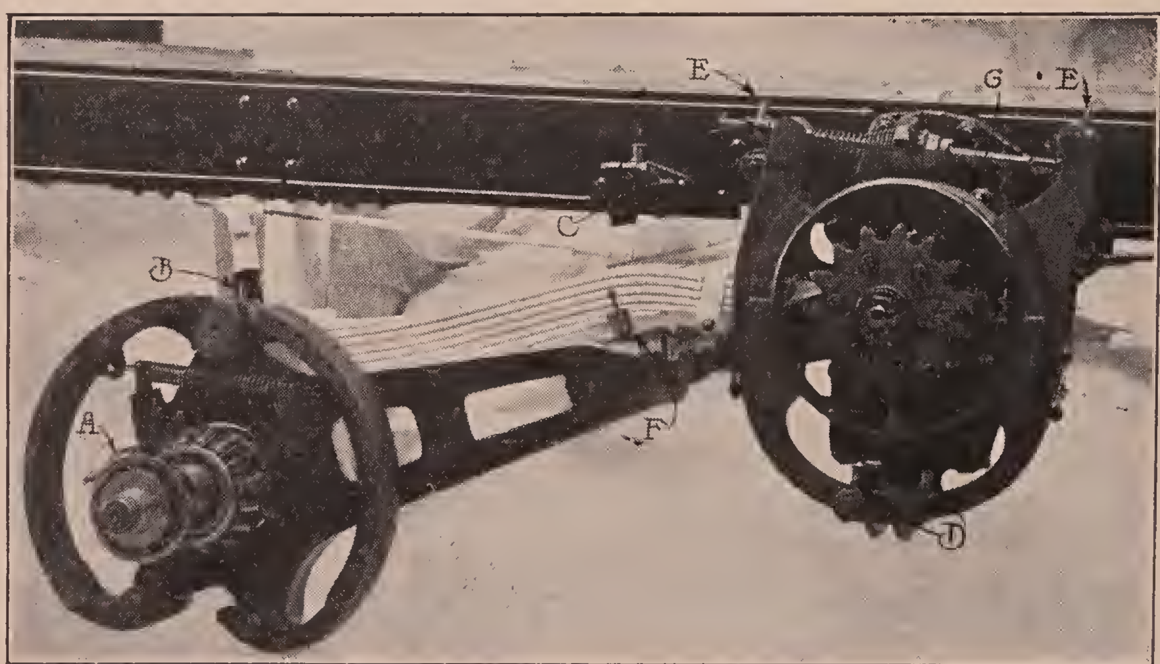


Fig. 102.—A Motor Truck Rear Axle and Countershaft, Showing the Places to Be Lubricated and the Manner in Which It Is Accomplished.

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**265. If the steering gear works hard?** This may be because of a lack of lubricant. The steering gear usually is packed with a heavy grease about twice a season; some but once a year. If this grease gets hard inside the case, it is almost useless. This frequently happens, and as soon as it is partly removed and partly cut by means of a thick oil of more fluid grease, the hard turning disappears. In an extreme case, the interior of the case might be dry, either through using up too small a supply, or through leakage.

**266. When an engine using the splash system of oil smokes all the time, what can be done?** Reduce the amount of oil in the crank case gradually, drawing off a little at a time, until the smoking discontinues. In doing this, use great care to note that the cylinders and other internal parts are getting enough before taking the last two or three drafts.

**267. When a motor with a gravity feed tank smokes too much?** In this case, the flow from the gravity tank to the cylinders should be reduced. If there is no cock or other adjusting means, a gasket should be put into the pipe joint with a smaller hole than that through the pipe. This will reduce the flow in proportion of the hole in the gasket to the previous internal diameter of the pipe.

**268. When a system with a mechanical oiler smokes too much?** Open the oiler and cut down the throw of the small pistons on each of the various feeds.

**269. With a pressure pump oiling system smoking?** Cut down the flow—at the pump, if possible; if not, follow the gasket method outlined in 267.

**ON THE JACK-SHAFT BRAKE,** the oil cups at the bottom pivots *D,* and at the upper bearings points *E,* should have the same treatment. The grease cup at the forward end of the radius rod *F* should have half a turn every 500 to 600 miles, while the larger grease cup *G* for the countershaft outer bearing (hidden from view, but located at about the point of the arrow), should have almost one full turn each day.

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**THE FRONT AXLE** is handled in the same way. Fig. 103 shows one of these, this, like Fig. 102, being of a well-known 3-ton truck. Except for size and materials, it is the same as any front axle, and hence will answer for lubrication directions. Although these cups look small, they are all grease cups, and should be turned up each day or when the day's work is short, every 150 to 200 miles for touring car, 80 to 100 miles for the truck. The wheel bearings have been mentioned previously. The cups *A* are for the inside bearings on which the steering knuckle turns, those at *B* are for

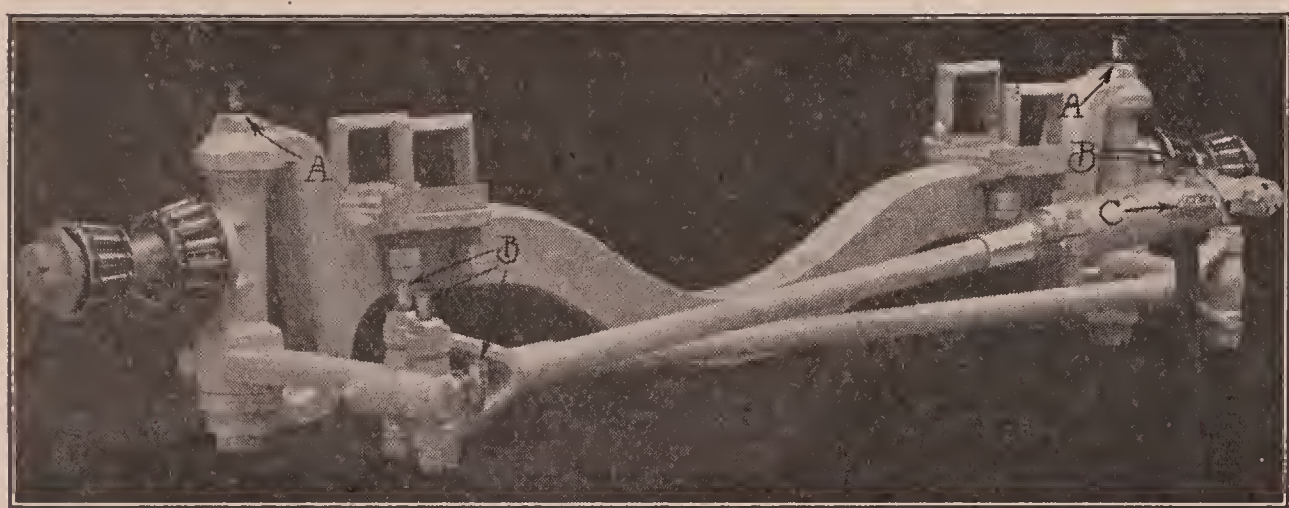


Fig. 103.—Front Axle of the Same Truck as Shown in Fig. 102, Indicating the Grease and Oil Cups.

the joints in the system of operating rods, and the bigger one at *C* lubricates the ball or universal connection with the steering rod. The springs are not shown, but the shackles carry grease cups, which should have half a turn every day, while the leaves should be lubricated every 1,000 miles. This is accomplished by jacking up the frame, above the springs, and separating the leaves by means of a screwdriver or other pointed instrument of special spring leaf spreading tool. Then the graphite grease—or pure graphite, some prefer—is introduced, the quantity depending upon the condition of the springs.

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**THE BEARINGS AND JOINTS** of the operating levers and pedals, for speed changing, brakes, clutch, accelerator, and others, should have oil about every 400 to 500 miles, the same applying to the other joints in the operating rod systems. The clutch shifter—that is, the part connected to the clutch and actually causing its movement—should have attention more often for best results. The steering gear case is usually filled up with grease or graphite grease once or twice a season, although the makers advise

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**270. Why is it necessary to cool automobile engines?** So much heat is generated in the explosion and expansion of the gases that not all of it can be carried off in the exhaust. The explosions come so close together that the cylinder walls do not have time enough to carry off the remaining heat by convection or conduction, consequently it piles up, so to speak, and the walls get hotter and hotter, unless some agent be used to carry this heat away practically as fast as it is created.

**271. If this is not done, what happens?** The piston expands more quickly than the cylinder, and soon reaches a point where it is as large as the hole in which it is sliding. Consequently, it refuses to slide any more, or sticks. When a piston seizes in this manner, it is a serious matter and wants attention of an expert immediately.

**272. How can this situation be brought about?** By forgetting the cooling water when that gets low, or when there is a leak in the system, or when the work has been unusually hard, calling for a high speed on the part of the engine for a long period of time.

**273. How can a similar situation be brought about on an air-cooled engine?** By a break in the blower driving shaft, if the motor is blower cooled; by a paper or anything of the sort stopping up the holes in the front end of the motor compartment where the air enters, or by cutting off the air supply in any way.

attention every 1,000 miles, or once a month. If the lubricant is not too thin, little if any of it can leak out, and when filled up very full, it can safely be left alone for a couple of months at a time. Packing the various leather boots—the two for the steering system, and those for the universal joints—may be handled in the same way.

In general, the operator should learn the external cups, which should have a turn or part of a turn every time he goes out; those which require attention, only every other time; the ones which come due weekly, while the bigger but less frequent jobs will take care of themselves. Each time before starting up, it is a matter of but a minute's time to go around those which are due, giving them each the required turn. This method of procedure is simple, quick, takes little or no time, and does the business. After getting the habit, one does it automatically, like setting spark and throttle levers before cranking, or measuring the gasoline before starting out.

Lubrication should be looked upon as a preventative, not as a task or a duty. The owner of the car should say to himself: "If I don't oil this brake, it won't work right; if I don't grease those springs, they will squeak; if I don't oil my motor right, it will seize, and I may have to buy new pistons and rings, possibly new cylinders." Viewed in this light, a simple turn of four or five grease cups to save a good many dollars is the best kind of insurance of economy, coupled with pleasure and comfort in touring. Aside from the cost and delay of replacements, the better and more thorough the oiling and greasing is done, the more easily and quietly the car will run.

**THE CHASSIS DIAGRAM,** seen at Fig. 104, will be of considerable interest, and will assist to make what has been said about the various parts previously more clear. In addition, it gives the novice all of the foregoing information at a glance.

Nothing has been said, and nothing will be for the quality of lubricants or the different brands, for we hold no brief for any manufacturer. In general, that oil, grease, or other lubricant should be selected which the makers advise will give best results. By this, reference is had to car makers, although the advice of lubricant firms may be heeded. It is a matter in which each and every owner must use his own judgment, supplemented later by what his experience has taught him. In general, use only the best, regardless of price at the outset. Also at that time use it freely—that is, do not be sparing of quantity. Later, with increasing experience, the owner will be able to cut down the quantity for economy's sake, while further cuts by the use of lower-priced forms will be possible. Every owner should keep an accurate account of his lubricants, as to cost, quantity used, mileage obtained, bad results, if any, improvements over the previous kind, etc. By consulting this record, it will be possible for him to determine at any time whether the use of a lower-priced lubricant has been profitable or otherwise.

**COOLING** is made necessary by the tremendous temperatures involved in the engine cycle. Thus, the explosions which follow one another so closely generate a great amount of heat which is not carried off in the exhaust. The result is to heat up the cylinder walls, pistons, rings, valves, inlet and exhaust pipes, and other parts of the motor, this growing rapidly worse

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**274. If a pump shaft shears off?** This is not as dangerous as might be supposed, for if the system is well arranged with large pipes of few bends and a fairly large radiator, the system will continue to work, operating on the thermo-syphon plan, if there is a passage through the pump for the water.

**275. In the thermo-siphon system, how is the water circulated?** When water is heated, it becomes lighter, and rises. If there is a source of cool water connected to the bottom of the part in which the water is heated, cool water will at once flow in to take its place. This in turn will be heated, rise, and cold water take its place. Thus, a circulation is established, the rapidity of motion depending entirely upon the amount of the heating. If this is great, as when the engine is working very hard, the water is heated very rapidly, and consequently rises and circulates with greater rapidity.

**276. Suppose an obstruction got into one of the two pipes from the cylinders to the radiator in the thermo system, what would happen?** The motor would begin to heat up at once, and, if not noticed by the driver, eventually the pistons would seize.

**277. How is this prevented?** The pipes are made so large that it would be practically impossible for anything to get in of such a size as would clog them, unless it were put in purposely.

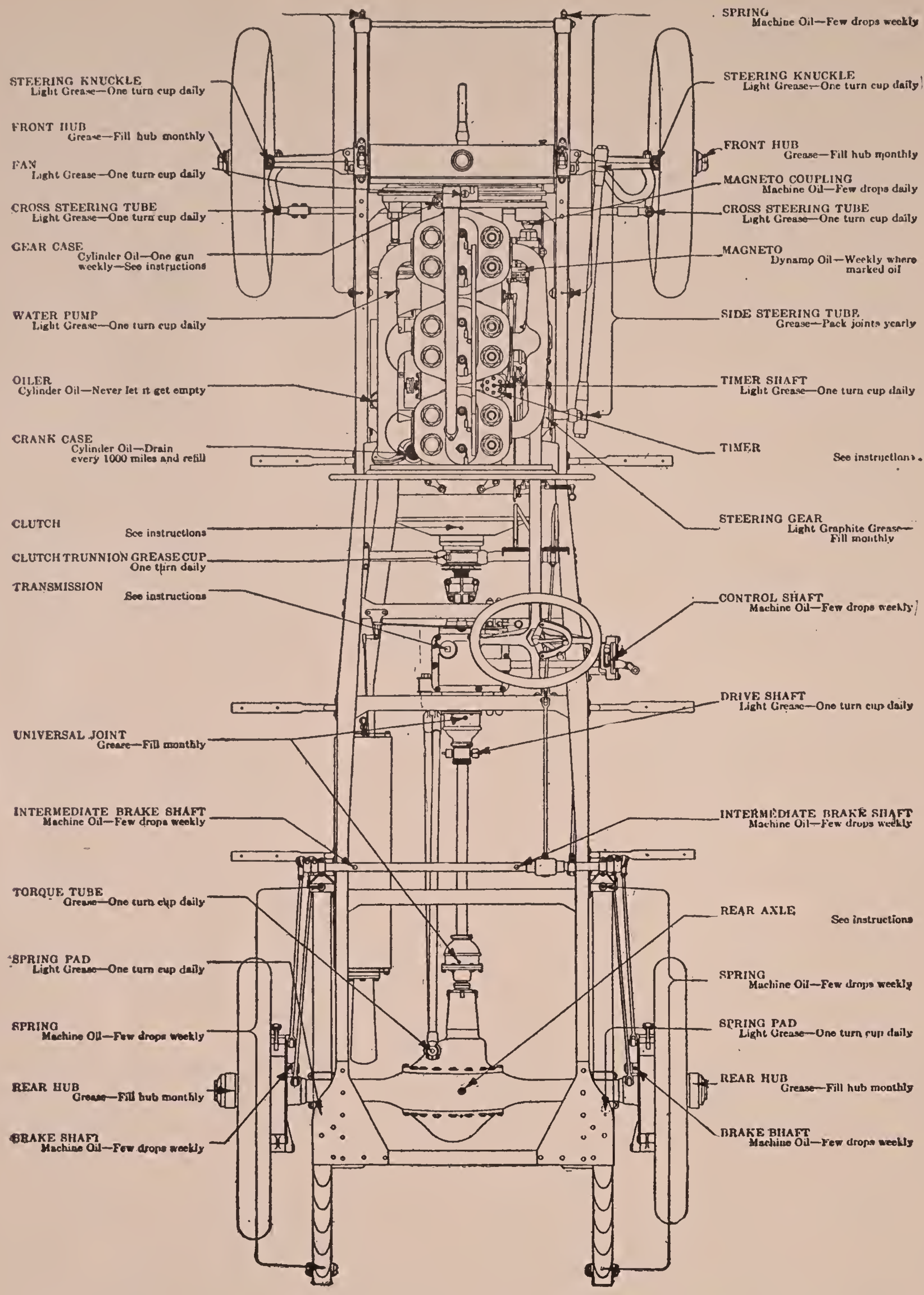


Fig. 104.—Diagram of an Entire Chassis, Giving Lubricating Directions for All the Important Parts.

**278. What precautions should be observed with the cooling system?** For one thing, no oil should be allowed to get in, for this will spread out over the surface of the radiator, and practically nullify the surface it covers, in so far as radiating surface is concerned. A very small amount of oil or grease will make a good-sized radiator temporarily useless in this manner.

**279. How can the driver get this out?** By boiling out the system with a hot soda solution. This is a good plan, anyhow, as it takes out all the dirt which has been deposited in the various corners and pockets of the system, and leaves the whole interior clean and thus capable of being cooled more efficiently.

**280. When the radiator heats up to the point where steam issues?** The driver should proceed slowly to a source of water. The slower he runs, the less he will heat up his engine. Then he should open the radiator by taking off the cap, and allow it to steam as much as it will, and cool off. When fairly cool, water should be added, a little at a time, so as not to chill, and thus contract and possibly crack the cylinders.

**281. In doing this, what precautions should be observed?** For his own sake, the driver should be extremely careful in taking off the radiator filler cap, as he is very likely to have the pressure of the steam formed within blow it off unexpectedly and burn his fingers at the same time.

as the engine continues to run. As much of this should be conducted away as possible, and, next to making the exhaust valves and pipes as large as possible and keeping them open and connected with the cylinders for the longest possible time, this heat is conducted away by two means. These are direct cooling, by means of integrally cast or applied air-conducting flanges, and indirect cooling, by means of water or other liquid circulation, this in turn being cooled by means of air.

**AIR COOLING.** The first method is not in very general use now. It is called air cooling, and cylinders so made are called air cooled. There are two methods of accomplishing this. One is the casting of the cylinders with projecting fins or flanges, which are supposed to carry the heat away from the internal or working parts of the engine, whence the air currents carry off this heat by conduction. As might be supposed, these cylinders are difficult to produce in the foundry, hence the second method was evolved. This involved putting the radiating surfaces on the cylinders, in the form of spiral flanges of copper, with the ends cut to form a series of projecting fins, in the form of pins screwed into the cylinders, the radial form of these giving it a porcupine-like appearance, or in other forms.

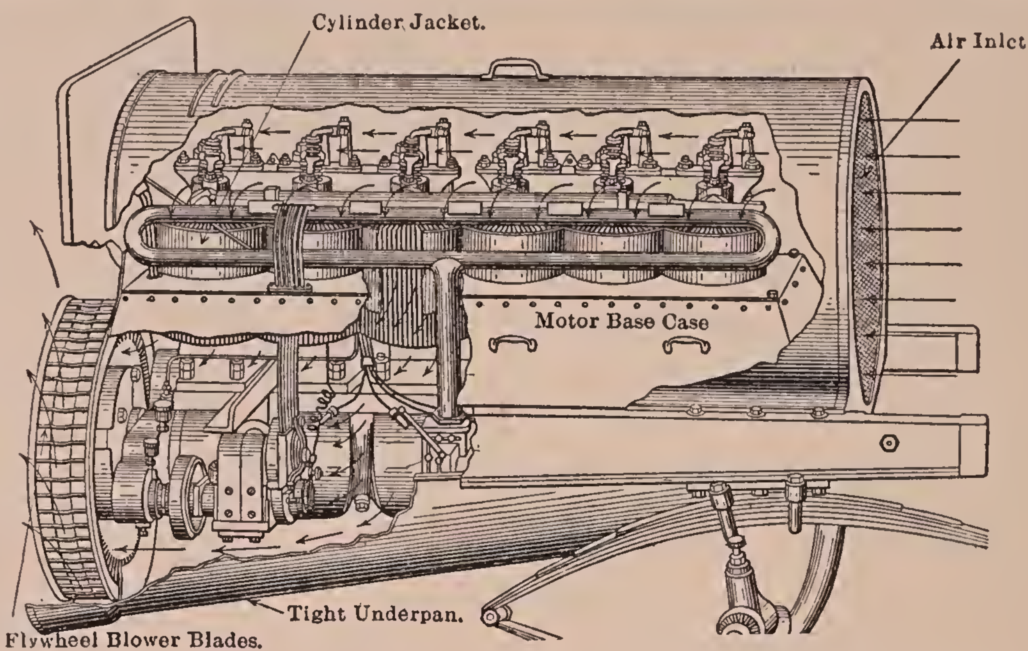

Fig. 105.—The Most Prominent American Air-Cooled Engine, Showing How the Air Is Forced to Pass Over the Cylinder Flanges.

In all of these, entire dependence is not placed upon natural circulation of the cooling medium, air, but this is circulated past the flanges in various ways. In the Franklin engine, shown in Fig. 105, the flanges are set vertically, are surrounded by a jacket, open only at the top and bottom, while the bonnet enclosing the motor is made air-tight everywhere except at the front, where the air enters, and at the rear, where a highly efficient fan, placed on the exterior of the flywheel, draws the air through. In this manner, the air is forced to pass along the cooling flanges in its passage from the entrance at the front of the bonnet to the only exit at the flywheel.

In the Kelly engine, formerly called the Frayer-Miller, and up to a few months ago used on all Kelly trucks, the process is inverted. Instead of drawing the air over the flanges, a blower fan at the front end of the engine forces it over. This is geared up from the crankshaft, and forces a great volume of air over through the pipes to the cylinders, thence down over the flanges, whence it is allowed to escape at the bottoms of the cylinder air jackets. To further the method as much as possible, the combustion chamber is formed on the top of the

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**240A. If the engine stand a considerable time in cold weather, and then turns over very hard and is difficult to start?** The lubricating oil on the cylinder walls, piston, connecting rod and crankshaft bearings, and elsewhere has oxidized and thickened to such an extent that it increases friction and increases the turning effort required, rather than lessening both.

**241A. How can this be remedied?** As far as the cylinders and pistons are concerned, an injection of kerosene will cut the old and useless oil. This can be injected through the valve caps or through the spark plug openings. As it will vaporize and burn, the same as gasoline this need not be removed, as is the case with anything else which might be put in for this purpose.

**242A. As far as the crankcase, the shaft and bearings, how can the trouble there be remedied?** Empty out all the old oil that will run out and then squirt in as much kerosene as is possible. In the case of a few bearings, it will be possible to introduce this directly to them, while those bearings of the connecting rod may be reached by turning it over slowly until they come to the bottom position, one after the other, and can be reached while there.

**243A. After all this has been done, what is next?** Replace the crankcase and fill it with clean, fresh oil. Then start the motor and run it for a few moments; when all the kerosene will be burned out. If the engine acts at all sluggish, or does not warm up well, stop it and while still warm

cylinder head with the valves set horizontally in this. The result is that the cold blast of air meets these most highly heated parts first.

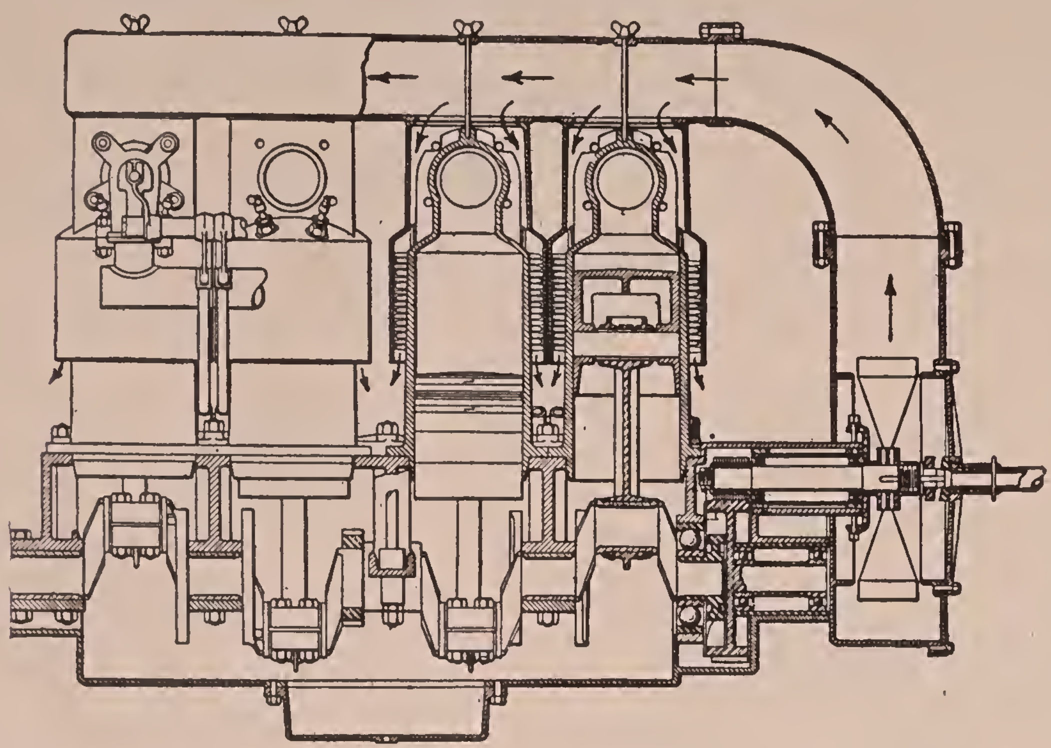

Fig. 106.—The Next Most Prominent American Air Cooler, Indicating How the Same Result Is Obtained Through the Medium of a Tremendous Forced Blast of Air.

Aside from the simple method of casting on the flanges and providing a large fan to produce a draft of air past the same, as shown in Fig. 107, the only other method used is that of inverting the process of forcing air against the cylinders by forcing the cylinders against the air, so to speak. By this, reference is had to the engine in which the cylinders are rotated, these being made with radial flanges.

Generally, this is now spoken of as a rotating engine, and it is exemplified in car construction by the Adams-Farwell motor, which was built in five- and seven-cylinder forms, and in aeroplane construction by the Gnome and others.

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**WATER COOLING.** In actual practice, it has been found that the results which can be obtained with the limited area of the flanges makes this air cooling a somewhat unsatisfactory system. Moreover, with the air-cooled form of motor, it has been found that the cylinders expand under the great amount of heat present, a sufficient amount to allow of a loss of compression, and, thus, a reduction of power. A further item is that no matter how well made and quiet at first, the air-cooled motor soon gets noisy. For these reasons, it has been found advisable to resort to the indirect method of cooling the cylinders with water, and then cooling the water by means of air, instead of using the air directly.

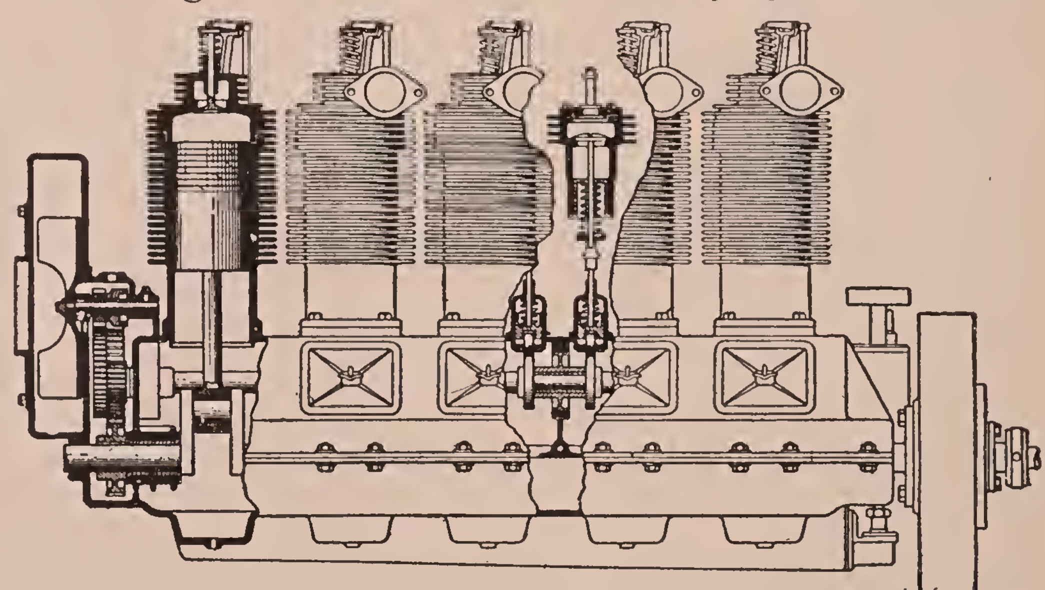

Fig. 107.—A Simple Air-Cooling Method for Contrast. The Fins Are Cast Radially, and a Fan at the Front Draws in Air, There Being No Other Provision.

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inject additional kerosene. After this second dose, applied while the cylinders are still hot, there will be no trouble.

**244A. Under similar circumstances, how should the transmission be treated?** All the old grease and oil should be removed, and the case cleaned out thoroughly with kerosene. This is especially important for the wear of the gears produces a fine metal dust which collects in the oil, but is deposited when it stands, in the bottom of the case. It is important to get all this out. When that has been done, the new lubricant may be introduced. If the lighter and heavier kinds are mixed, the lighter should be put in first, and the car run a short distance with it alone; then the heavier portion added. The idea is to work the thinner lubricant thoroughly into all the bearings, sliding parts and all parts which move or work, or need it in any way.

**245A. What is the usual method of proceeding with the steering joints?** These are covered generally with a leather boot, which is packed with grease and then closed for the season. At the end of each season's running, they should be emptied, and before the beginning of a new one, they should have the boot taken off and a light oil worked into all the joints and moving parts. Then the boot is replaced and refilled with the usual grease, packing it as full as will close up well, and lacing it up tightly.

The greater efficiency of this comes in the possibilities for greatly increased cooling surface available in a radiator, as compared with the small area available on the cylinders themselves. Water, as a heat-conducting medium, has many times the ability of air, so that a much smaller quantity will carry away a much greater amount of heat. The tremendously increased radiating surface of the ordinary motor car cooler or radiator is what enables this to be removed from the water in turn, so that it takes up the cycle again fairly cool, although not as cold as it was in the beginning.

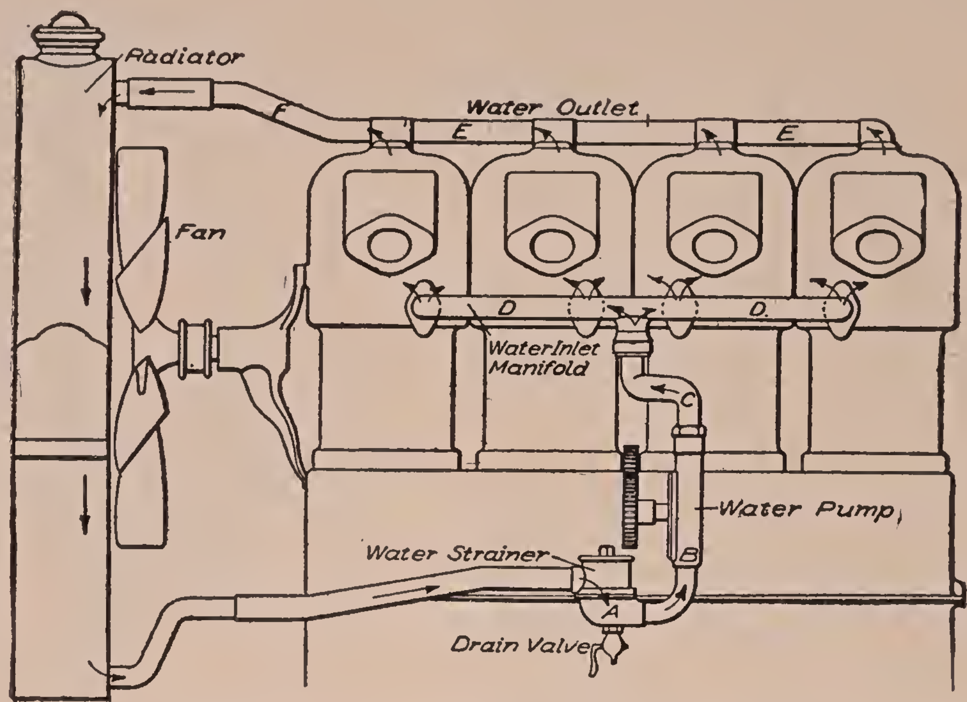

Fig. 108.—Diagram of Any Water Cooling System, Indicating the Principal Units, Radiator, Fan, Pump, Strainer and Piping.

There are two methods of circulating the water: By pump, and through its own rise in temperature. The former is more general, and is considered more efficient. In this, a pump—of the vane, centrifugal, or plunger type—draws the cool water from the bottom to the radiator, pumps it into the lower parts of the water jackets on the cylinders, whence it absorbs the excess heat, passes on to the top, and out through another pipe to the top of the radiator. There it is cooled, falls to the bottom, and starts around the cycle again. In a system of this sort, as shown in the diagram, Fig. 108, aside from the cylinders themselves, there is needed the radiator or cooler, the pump, the piping with a drain cock at the lowest point for drawing off the water, and the fan. The first is the most important and one of the more costly units in the motor car. Generally, it is constructed from copper and brass, both costly materials, and in such a way that all of the joints have to be soldered or brazed by hand, which also adds materially to the expense. Such a radiator is shown in Fig. 109, this being of the so-called square-tube type. It is called this because the air holes through the radiator form a series of squares,

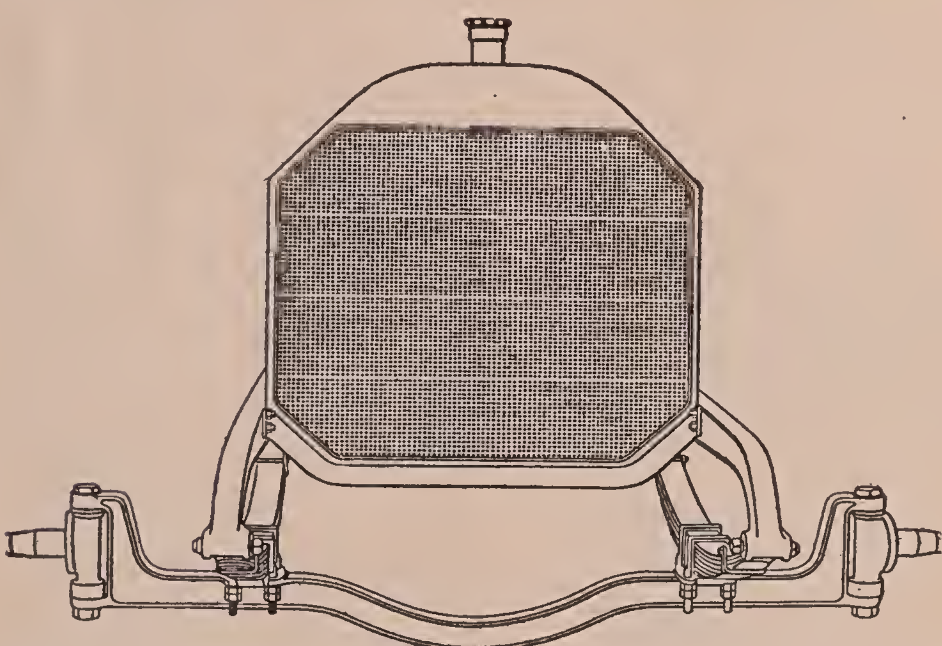
Fig. 109.—A Typical Radiator of the Square Tube Honeycomb Type, Indicating Enormous Radiating Space.

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**246A. Is there anything about these boots which requires special attention?** No, except that they be whole and not torn, cut or gashed in any way that would allow the grease to escape. It is well, also, to clean them after emptying in the fall, as they collect a lot of dirt during the year's running, dirt which water alone will not take off. This should be removed in its entirety, to prevent the possibility of the same being ground into the bearings with the grease.

**247A. When lubricator glasses give trouble, how can this be remedied?** If this is due to the glasses clouding up, this can be removed by taking the glasses off and cleaning them thoroughly. It is a good idea to rub the surface over which the lubricant passes with a little glycerine. This will not keep them from clouding entirely, but will help keep them clear for a considerable length of time.

**248A. How is grease gotten into a more or less inaccessible place which is supposed to have a lot of it?** In such cases as a differential, which takes at least a pound of grease at the beginning of each season, and which oftentimes has a small hole, not over one inch in diameter, the grease should be forced in by means of a so-called grease gun—that is, a gun for handling heavy liquids which is provided with a form of handle or crank which allows of applying pressure to the contents so as to force them out through the long spout. There is a form of

which give the front of the car a very pleasing and uniform appearance. When these holes are formed by round pipes, the radiator is called a honeycomb type, a name which was applied to it many years ago when it was first brought out, but which is now going out. A third and very cheap type, used only on the lowest-priced cars, and on very few of these, consists of a series of round, flat metal discs, soldered onto the outside of a continuous copper pipe. These flanges are set equal distances apart, while the copper tube is coiled, wound, or folded to some convenient shape.

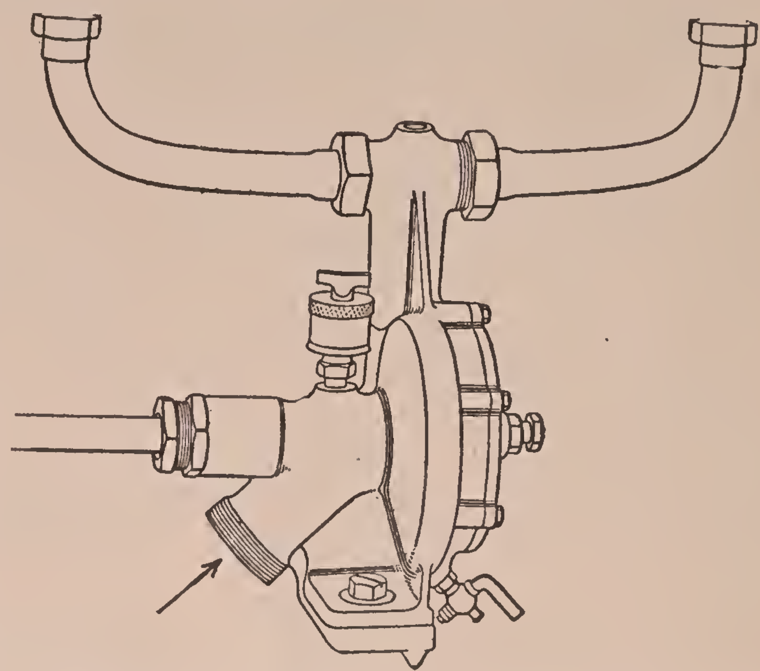

Fig. 110.—The Centrifugal Pump, Used with the Radiator of Fig. 109. Compare This with the Other Pumps.

Next in importance comes the pump. As has been stated, this is generally of the centrifugal, vane, gear, or plunger type, the latter being used very little. Fig. 110 shows one of the centrifugal type, this being the most popular form. Although this does not show the interior but only the exterior and the piping, its working is easy to explain. The impeller consists of a series of blades with considerable width, these being curved to the form which will throw water most efficiently, as determined in water turbines. That is, these are small turbines, but inverted so that the turbine drives the water instead of the water driving the turbine. The case is formed to admit the water to be impelled at the most advantageous point, and is shaped so as to carry it off with as few bends or curves as possible.

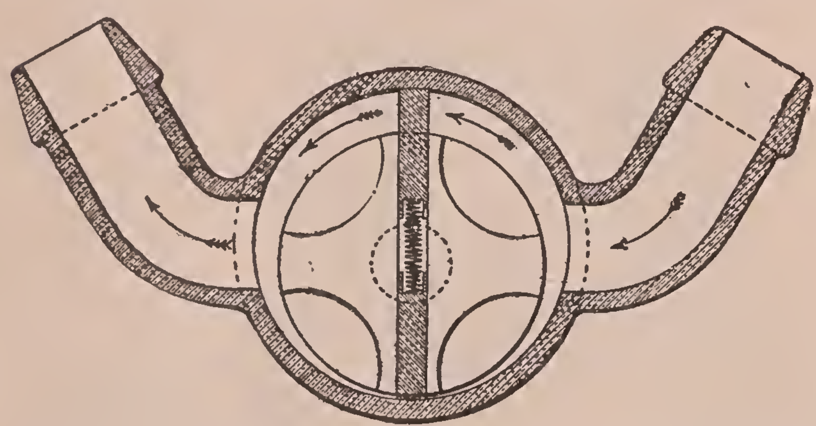

Fig. 111.—Section Through a Vane Type of Pump, Indicating the Sliding Vane in Two Parts and the Spring Which Keeps Them Separated.

The vane is not different from the centrifugal in action, but has a single central boss, in which a vane slides back and forth as the shape of the chamber in which it is rotated allows it to expand or contract, a spring between the two parts of the vane allowing this action, as shown in Fig. 111. Where the case is narrow and the vane must contract, the water is admitted, and carried around to the wider part, where the vanes expand and throw off the water by centrifugal action. That is, in the vane pump a single sliding vane takes the place of three, four, or more arms on the centrifugal type, although the actual forcing of the water is a centrifugal action in both cases.

This is made clear in Fig. 111, where the vane type is shown in section with the vane at its point of maximum extension. Beyond this point, the sides of the case contract it gradually, at the same time forcing out the water.

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grease pot marketed, which holds five pounds of grease and has a long flexible metal hose, made especially for filling differential cases of this kind. In general, if there is no instrument of this kind at hand, force in grease by hand until the patience is exhausted, then squirt in a considerable supply of a lighter oil, using an ordinary oil can. While perhaps a little too light at first, this will soon mix with the grease and thicken up.

**249A. On a long tour, when the supply houses are liable to be somewhat far apart, and with a motor which does not hold a great deal of oil, what plan is advisable?** In such a case, it is well to carry along a couple of sealed cans of the oil used, in addition to a full motor, or motor and tanks, in case the car is fitted with tanks. If this plan is not favored, there is on the market a type of oil container called an emergency oil can. These are made in a variety of sizes, and one should be obtained sufficiently large to carry the motor to the next source of supply. On the long stretches of desert and plain of the far West and Southwest, it is necessary always to carry extra oil, gasoline and water, since these are not obtainable at times for a distance of 300 miles or more.

**250A. What is an air lock?** This is a body of air entrapped between two columns of water in a motor-cooling system.

**IN THE GEAR PUMP,** an example of which is shown in Fig. 112, a pair of gears of equal size, each with a very small number of teeth and of a special shape, mesh and rotate continuously. Water is admitted on what might be called the back side of these gears, flows into the spaces between the teeth, is picked up and forced along, the action of the rapidly rotating gear teeth partaking to a large extent of a centrifugal action in throwing off the water. This probably is the simplest form of pump in use, but the disadvantage lies in the fact that a small piece of wood, a sliver of metal, or other foreign matter in the water will put it out of business temporarily, and while it is disabled thus, no water can flow through it. With the plunger the same is the case, but not so with the vane and centrifugal types.

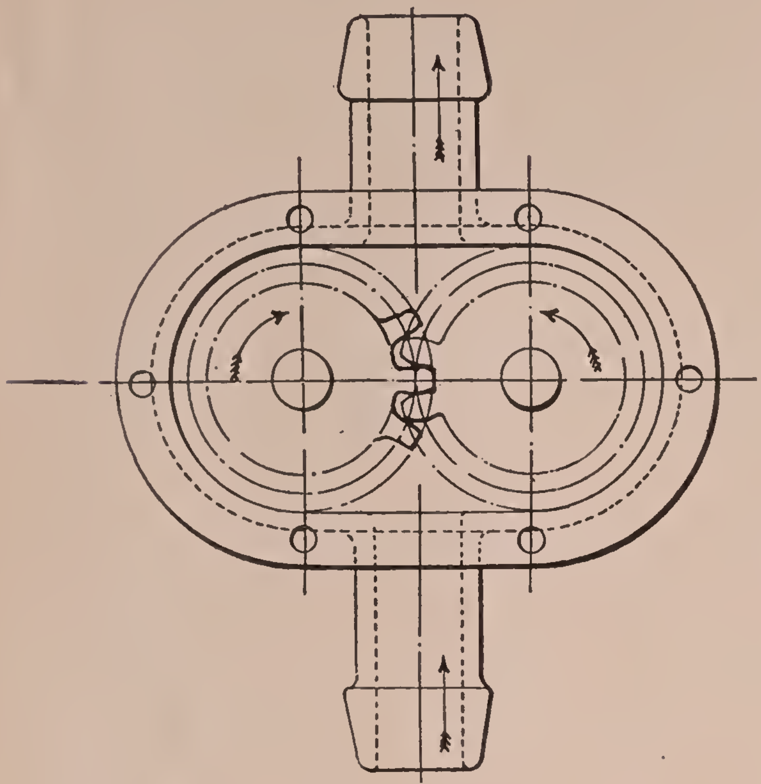

Fig. 112.—Gear Pump, in Which the Teeth Are But Indicated, Not all of Them Being Shown. Water Enters at the Bottom and Is Forced Out at the Top.

That is, the two latter will allow the water to pass through on the thermosiphon principle, even though they do not operate. Plunger and gear will not do this.

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**COOLING FANS** are not used on all cars, some designers considering them superfluous with a large radiator and good-sized pipes. Others leave them off to save the additional parts and the weight they add. In general, their necessity is recognized, and they are used on the majority of cars. The forms in Figs. 113, 114 and 115 will give some idea of the great difference in their construction. That in Fig. 112 belongs to a well-known American four-cylinder car of low price. The fan is of pressed steel with six arms, riveted to a cast central spider, and is belt driven from the crankshaft to give a high speed of rotation. The one seen in Fig. 113 is from one of the newer low-priced French cars for the 1914 season, and is of cast aluminum with the fan pulley cast integral. It has four arms, comparatively short, is enclosed in a housing to make the air suction more efficient, and is driven fairly fast, but not as fast as the previous one, despite its smaller diameter. This view also shows the pump and an exceedingly simple piping scheme. In Fig. 114 is shown another European fan layout, this partaking more of the aeroplane propeller type. The fan has but two blades, a casting but bolted to the fan pulley; they are of large diameter, and are driven at a high speed of rotation. In addition, the back of the radiator is housed in to make cooling more efficient.

This housing in of the back of the radiator is showing such a greatly increased cooling efficiency for the whole system that it promises to be very general in 1915. It forces the air to pass through all portions of the radiator.

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**251A. What does this do?** It prevents the passage of either column of water, and consequently, stops all circulation of water and all cooling of the engine. In this way, the latter heats up very rapidly, and if not noted and remedied, the pistons are liable to sieze.

**252A. How can this be remedied?** Usually such a lock will occur at the lowest point of the water system, particularly if there is a sharp or deep bend in the pipe there. The remedy is to place a pet cock at that point, and whenever the water stops circulating and an air lock is suspected, open this cock. If the suspicions are correct, the air will then flow out, followed by the water. As soon as the latter starts to flow the cock can be closed. When the engine is started up again, the air lock will be found to have disappeared.

**253A. Is there any other point except the cylinders, where an air lock is liable to do particular damage?** The pump is very liable to be the first part to heat up, due to the fact that it is rotating at the usual high speed, but is not circulating any water. When this heats the shaft is very liable to sieze, and if not stopped or cooled off, to shear off. This complicates the trouble, for the pump is useless until a new one with a new shaft can be obtained and fitted into place. Of course, the motorist can take a chance by operating the car without a pump, on the assumption that the water will con-

**USING LEATHER BELTS** in a position where a great deal of water is spilled in filling the radiator, fan belts naturally stretch a great deal. For this reason, there must be provided some means of increasing the tension by moving the fan up higher. There are several methods of doing this, that in Fig. 114 being by means of a supporting lever, the fan being set on one end of this while the other end is moved to change the tension. Lowering the long end raises the end on which the fan is, and consequently tightens the belt. A spring is used normally to hold the tension, but when the belt loosens up beyond the ability of the spring a nut is tightened which causes the spring to exert still more pressure. In Fig. 115, the method of tightening is the use of an eccentric bolt. When this is turned, the fan is raised or lowered, and the belt tightened or loosened, according to the direction of turning. Normally, this is held tightly, but when the belt needs attention, it is loosened up, the member turned until the tension is right, and then tightened again. As compared with the former, it has the advantage of greater simplicity, fewer parts, and occupies less space.

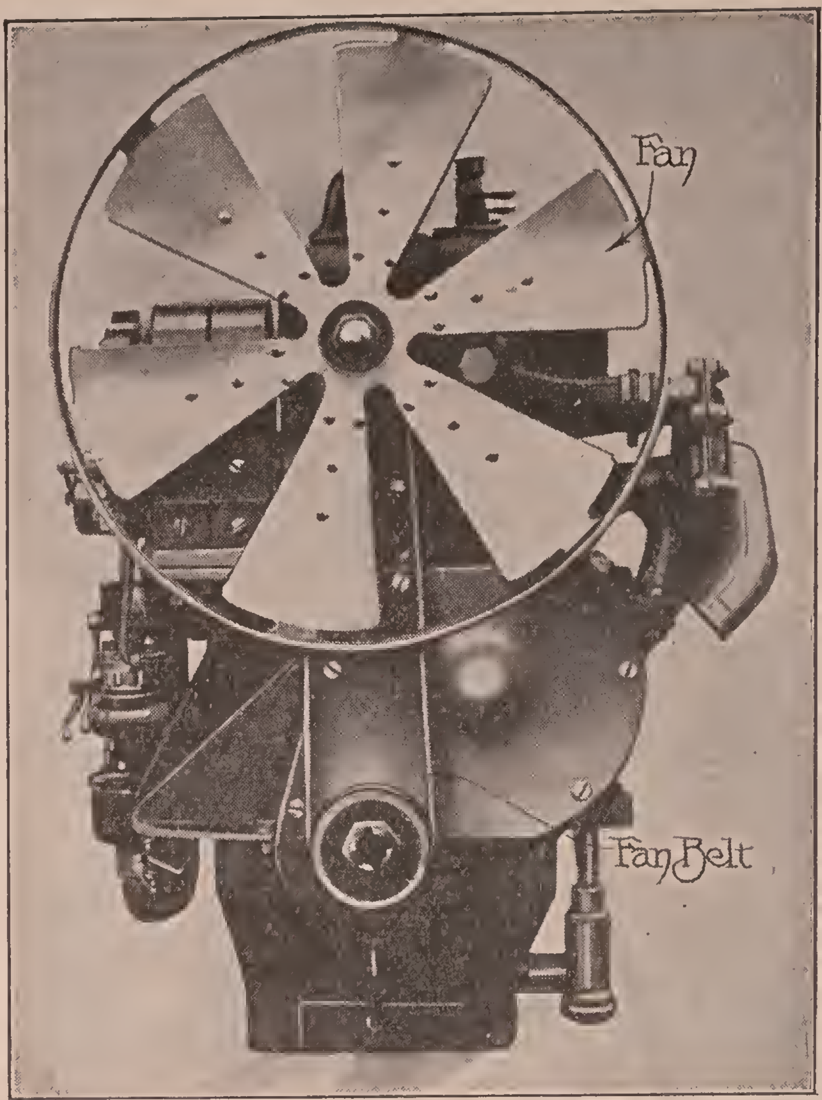


Fig. 113.—A Typical American Fan Layout, with Six Blades and Flat Belt.

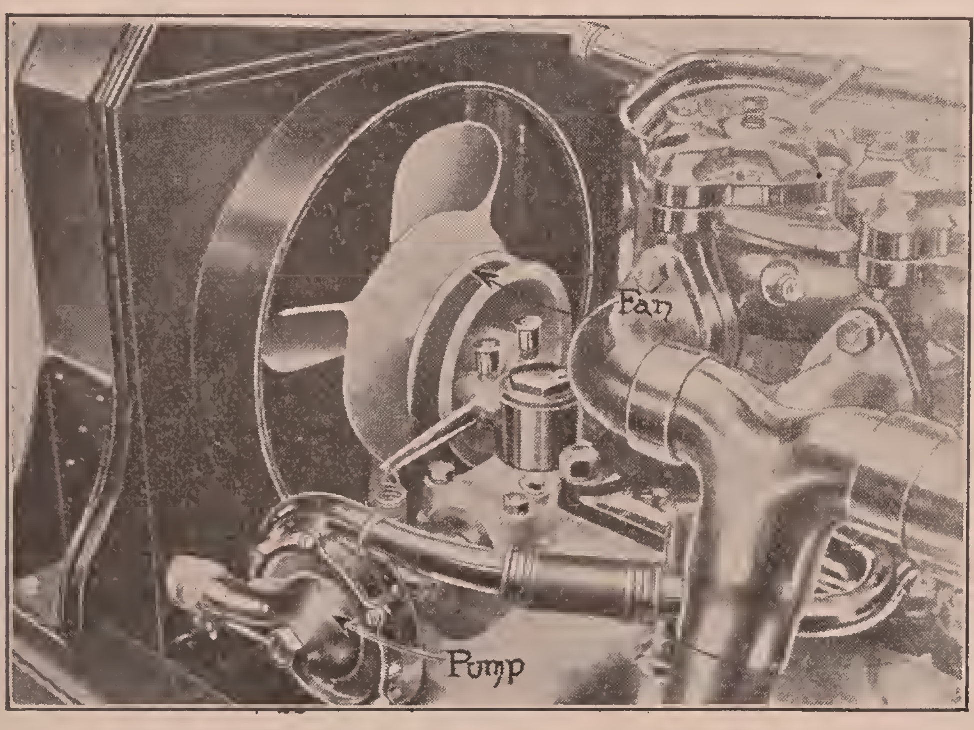


Fig. 114.—A Foreign Fan Layout, in Which the Shrouded Radiator Makes the Fan More Efficient.

When water is heated, it becomes lighter, and tends to rise to the top of the vessel in which it is confined. This well-known action is made use of in many house heating systems, a single pipe carrying the hot water

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tinue to flow by thermo-siphon action, but this is not advisable, for generally pump systems are made with very much smaller pipes, sharper bends and more of them, than thermo-siphon systems.

**254A. When a pump is lubricated by means of a grease cup placed close down to it, so close in fact that water forces up through the grease and escapes all the time, how can this be remedied?** Take the grease cup off, and fit a filler pipe a couple of inches long between it and the hole in the pump casing. Then, when the cup and pipe are filled with grease, the water will not be able to travel the additional distance up the pipe. Consequently the leak will be stopped.

**255A. After several bad bumps on the road, the radiator seems to begin leaking after the whole system gets heated up so that it is thoroughly hot. Then it will continue as long as the engine runs?** The trouble is that a small leak has been sprung in the radiator by the jolts of the road, either in a tube, or the solder surrounding the tubes. This hole is so small that when the water is cold it will not pass through. As the radiator heats, it expands and this hole is opened up. In addition, hot water is thinner and will pass through smaller holes than cold, so the two combine to cause a considerable leak at a point where there is

from the furnace, and the cold fluid going back to it. This same action is taken advantage of in the thermo-siphon system of cooling motor car engines. Larger pipes, larger water spaces throughout, short, simple piping without bends, and a greater quantity of water are the only changes from the pump circulating system. The action in this case, shown graphically in Fig. 116, is as follows: The cylinders heat the water, which rises to the upper pipe, while other water from below flows in to take its place, and, in turn, is heated and rises. The result is a steady upward flow of water, which passes over into the radiator, is cooled, falls to the water, and then is used again. The large size of the pipes, the few bends and those easy ones, and the larger water spaces provide for the expansion of the water and its consequent upward action with as little friction as possible. The radiator is set as high as possible, so that the actual rise of the heated water is small; in addition, this provides a slight head or pressure of water by which the colder fluid is forced up to the water jackets from below.

**THE THERMO-SYPHON SYSTEM.**

The advantage claimed for this system is the entire elimination of the pump, which saves also its mounting, driving means, lubrication, piping, etc., all of which add to the number of parts and particularly to the first cost, maintenance cost and weight. It is claimed also that the pump method of circulation may be too rapid, cooling the water too much, and making the temperature of the engine so low that its efficiency is reduced, while by the natural method it is kept as warm as possible at all times, the water circulating according to its heating. A disadvantage lies in the fact that the water is kept close to the boiling point all the time, and a very slight obstruction is sufficient to cause steaming. Since the amount of water present is small enough at best, as soon as it starts to boil away in the form of escaping steam the quantity is being diminished. This, if neglected, will soon lead to overheating, when the lubrication may not be sufficient to keep cylinder and piston apart, with the result that the latter seizes, as it is called, uniting firmly with the cylinder walls. When this happens, the operator should pour into the tops of all cylinders as quickly as possible a quantity of kerosene or the thinnest oil he can obtain, in the hope that this will flow down between the walls and pistons, thus freeing the

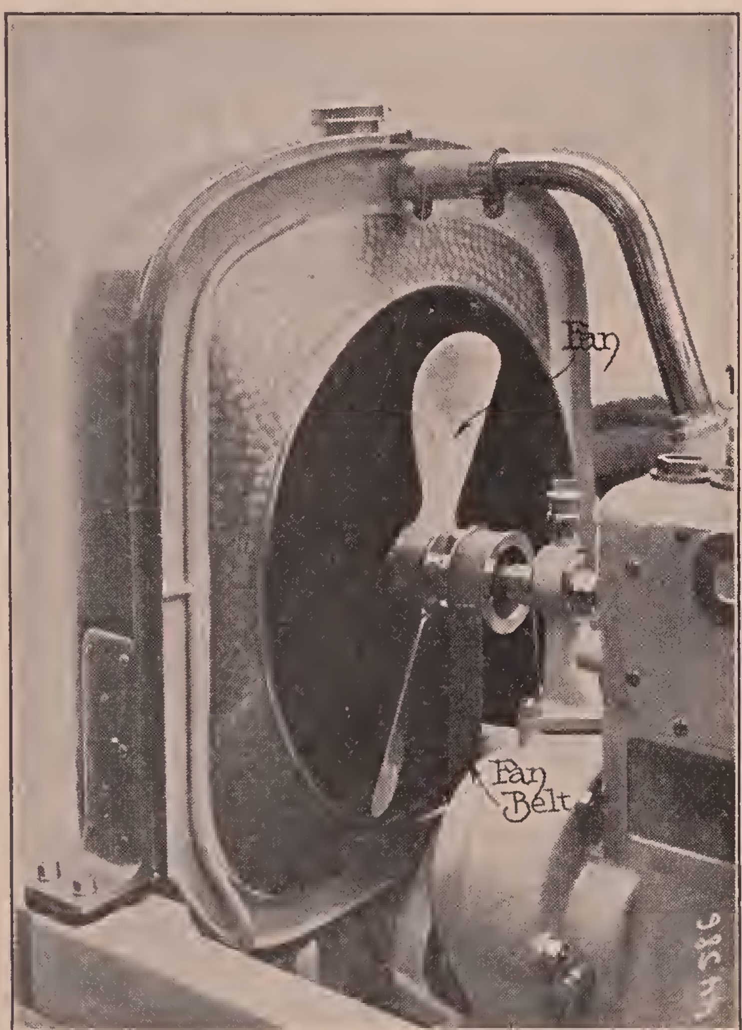

Fig. 115.—Another Foreign Design, with Much Simpler Lines and a Two-Bladed Fan.

none when the engine is started and both radiator and water are cold.

**256A. How can this be remedied?** There are substances which can be put in the water, and which will find their way to this point and seal it. A number of these, in the form of powders and liquids are now on the market. The best way, however, is to take the radiator off and have the place soldered. It is advisable first to determine it somewhat carefully when the radiator has heated up and the leak is apparent, marking this point so as to save the repairman much trouble finding it.

**257A. Suppose a piece of hose in the water system shows a leak and no materials are available to repair it, nor a new piece of hose to replace it?** Wind a couple of folds of cloth over the leaking part, drawing this as tightly as possible, and winding it on so the thick part where the folds lap one another comes directly over the hole in the hose. Then wind tire tape over this, making the tire tape fast to the hose before starting onto the cloth, and after covering the cloth, making it tight on the other side. If this is done with care, a repair will result which can be driven many miles without leakage.

**258A. Is there another way in which this repair can be effected?** Almost as good a way is to soak string or twine in grease or heavy oil and wind this around the pipe, allowing about three thicknesses over the

latter. Then a supply of water should be obtained, and poured in very gradually with many waits. If poured in too quickly, the cylinder walls, which are chilled by it, may contract quickly enough to seize the pistons again, this time in a grip which cannot be loosened so easily.

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**PROPER TEMPERATURE.** For normal running, outside of hard running in sand, mud, or the hard pulling of mountain work, the radiator should be just hot enough so a person can lay the hand on it, but cannot keep it there. If it is so cool that the hand can be kept there without discomfort, then the motor is being kept too cold. If it is much hotter than the hand can bear—that is, so hot it is impossible to touch it without being burned, the system is getting too hot, and additional cold water should be put in, a little at a time, as before. On mountain work, it is advisable to carry extra water, so as to be able to do this. There are times in heavy pulling when the system gets so hot that all water should be drawn off and replaced with cold. When this is done, the hot water should be drawn off first and the car with the cooling system empty allowed to stand for a few minutes before any cold water is put in. If this is not done, the water and the engine parts will heat up this cold water as fast as it is put in, and nothing will be gained.

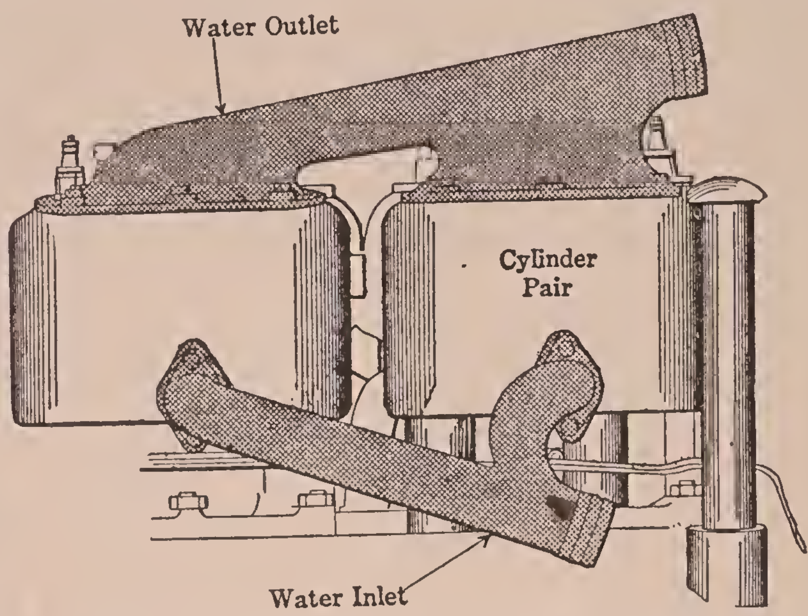


Fig. 116.—The Outlines of a Thermo-Siphon Cooling System, Showing How the Pipes Are Enlarged, Shortened and Straightened to Make the Water Passages as Simple and Direct as Possible.

So important has the cooling system come to be considered in the modern motor car that devices have been brought out which show the driver automatically when his system needs more water, indicating the temperature of the same to him at all times. For the beginning motorist these are excellent, and their use is advised strongly.

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break and gradually tapering out at the ends. This should be wound on carefully and as close together as possible, the ability of the repair to resist water from within depending upon the oil, or grease-soaked twine being close enough together so that water can not pass between.

**259A. Suggest still another makeshift repair.** An old inner tube can be cut up, so as to make a long, narrow strip or strips. One of these is wound on the cracked hose, much as a bandage is wound around an injury. Care should be exercised to wind this on as tightly as possible, stretching the rubber all the time. When several folds have been wound on, the outside edges of the rubber are fastened down by means of string, twine, wire or otherwise.

# CHAPTER VII.

# What Every Owner Should Know About Rims, Wheels, and Solid Tires.

**TIRES** were presented in considerable detail in Chapter II, but nothing was said there about their methods of fastening. There are a number of these, and as they are decidedly different and as their use necessitates different methods of handling, this will be taken up. In general, the first tires were of the clincher type—that is, made with a clincher attachment. In this, the bead of the tire is formed with a pair of lips, one of the outside of each bead to fit into a pair of corresponding recesses on the inside and outside of the rim. The latter was in one piece, consequently the tire had to be stretched in order to get it on. To make this possible, the beads were made somewhat flexible; but even with this advantage, it was a very tiresome, slow and disagreeable task to put one on or take it off. In fact, it was a question which was the greater job, to take it off or put it on.

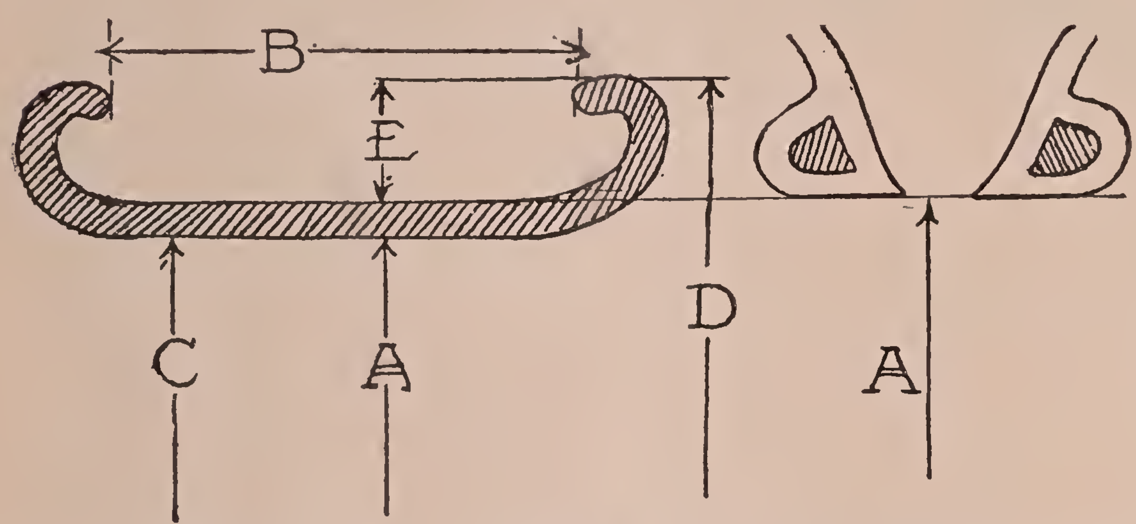


Fig. 117.—Section Through a Clincher Rim and Tire, Showing the Amount E Which the Tire Must Be Stretched All Around Its Circumference in Order to Get It on the Wheel.

The sketch, Fig. 117, shows the clincher rim and the base of the clincher tire. In this, *A* is the nominal diameter of the rim, by which it is generally spoken of; similarly *B* being the nominal width. The inside diameter of the rim *C*, and the extreme outside diameter *D* have no bearing on its general nomenclature, but the latter is highly important in putting on or taking off the tire. It will be noted that the extreme outside diameter *D* exceeds the inside diameter *A* by the amount *E* for its entire circumference—that is, it is that much bigger all around. Now the tire has as its smallest diameter the size *A*, corresponding to the inside diameter of the rim. In order to get the tire in place, however, each side of it must be stretched a distance slightly greater than *E*. That is, the small size *A* must be stretched to a size slightly larger than *D*, in order that it may pass over the edges or lips of the rim. Once in place, the same stretching process must be repeated in order to get it off, with this difference, that

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### How to Remedy the Most Common Automobile Troubles

**282. When a tire punctures, what is the reason?** The air escapes from its container because a hole or opening of some kind has been made in it. This may come from inside or outside; inside via too much pressure, a combination of weakness and high pressure, unusual heating causing undue expansion, unusual weakness or rotting due to dampness or other causes, etc. From the outside, it may be caused by any sharp object which has been forced through both casing and tube, as nails, screws, other metal objects, sharp-pointed stones, and any sharp or pointed animal or vegetable matter. Motorists have sustained a puncture from corn stalks when running across fields.

**283. How should this be fixed?** If the hole through the casing is small, the natural spring of the material in it and its many thicknesses will take care of that. Then there remains only the repair of the air bag or tube. This is cleaned, patched with a rubber patch, cemented in place with rubber cement, then allowed to dry and the job tested. The latter is advisable before inserting in the shoe, as otherwise the motorist will have to do the work of removal and inserting, no mean job with clincher and quick-detachable forms, twice over.

**284. When the hole in the tube is a fairly long one, as, for instance, 1½ inches long?** Trim off the edges so they will be smooth all around. Wash out the inside of the rubber with benzine then coat this with cement. Allow it to dry until sticky, this varying with the nature of the cement. Some kinds re-

there is less room to work and place the tools. The bead farthest away from the worker is put on first, commencing at any point by simply pushing the bead into the space in the rim. Then, holding this in place, the balance of the tire is pushed up as close as possible to the side of the wheel. Next, with a thin-bladed tool, the operator starts to work around from the part which is in position, sliding this under the bead of the tire and over the inside edge of the rim, and then lifting up on it, so as to stretch the tire. When stretched, a continuation of the same motion or any sideways movement with the same tool or a hammer, forces it along the tool, until it drops off, on the inside. This is easy enough until the width of tire still outside is reduced to about 10 inches in length. Usually, it is necessary to lift all of this over at one time, which means the exertion of considerable force in stretching such a length of tire. When it has slipped over, so that the entire inside bead of the shoe is inside the rim, this is forced over with the butt end of the tool, until it rests snugly against the rim on the opposite side.

In this position, the tire looks as shown at *B* of Fig. 118, *A* showing the position when forcing on the last of the bead. When this has been crowded over against the rim for its entire circumference, the inner tube is put in place, and the work of putting on the other bead begins. This is done in the same manner, *C* of Fig. 118 showing the situation at the start. The loose portion is put in place, and, working both ways from this, as much more is forced in place as can be done with the hands. When it is nearly all in, except possibly the last 10 or 12 inches, the tool and hammer come into play, alternately stretching and pounding it in, until the job is finished. In this work of putting on the outer bead, great care must be exercised not to catch the inner tube between the pointed inner ends of the two beads, or between the rim and any part of the second or outer bead. A good way in which to prevent this, in large

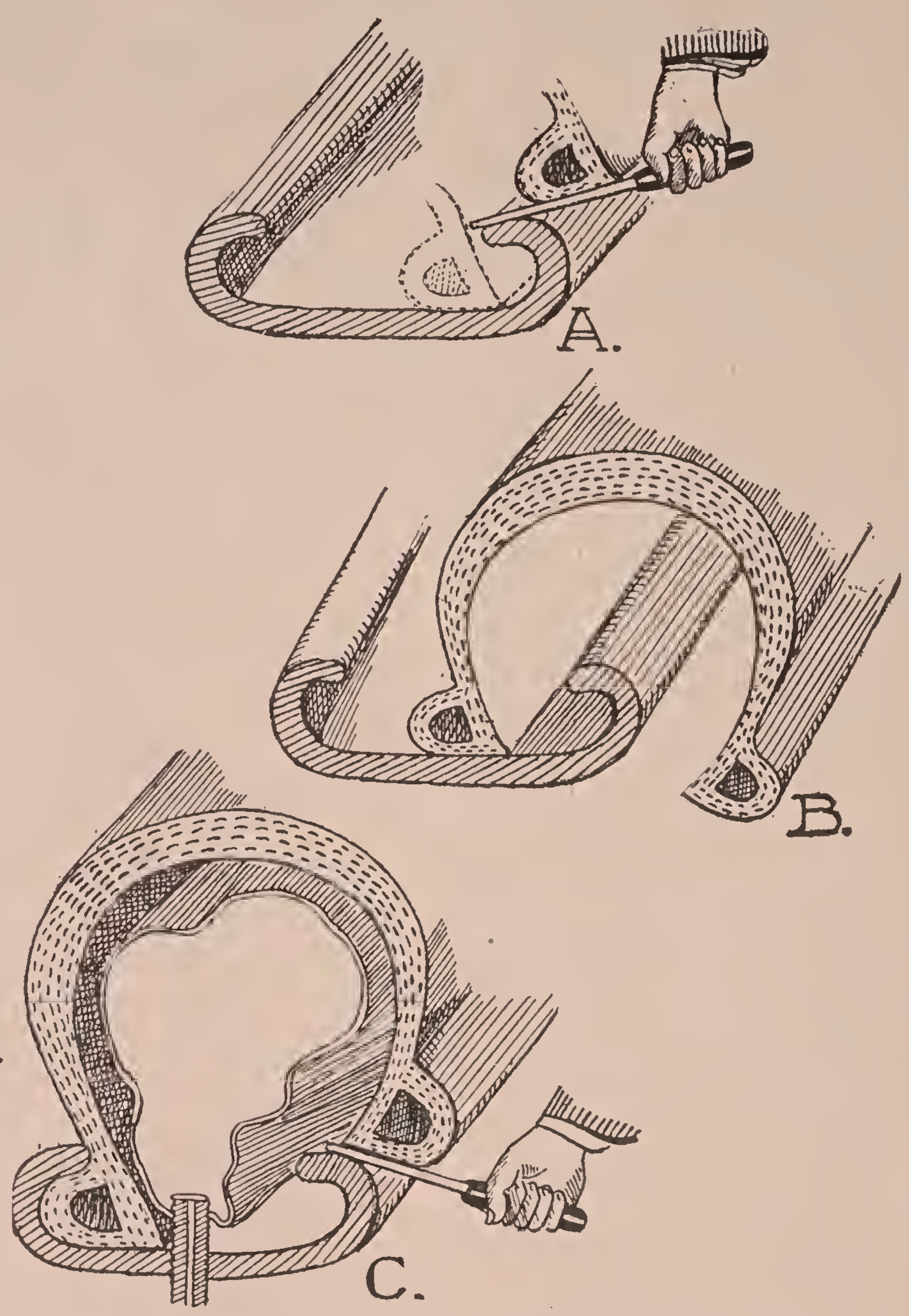


Fig. 118.—Putting on the Clincher Tire. First, the Front Edge with Its Fairly Stiff Bead Is Forced on Over the Rim, as at A, Using a Stiff and Strong Tool; This Gives the Situation Shown at B. Next, the Inner Tube Is Inserted, as Shown at C, and Then the Outer Edge Is Forced on in the Same Manner as the Inner.

quire 15 to 20 minutes; others as much as two hours. When ready, insert a patch which has been recently dipped in benzine. Make this from 1 to 2 inches longer than the hole and wider in a similar proportion. Cut it square, but trim off the corners to a round. Lay this inside flat and press the tube down on it, then fill the cavity in the tube with a good quality of rubber gum, prepared for this purpose, then cure for 15 to 20 minutes at 30 pounds' steam pressure, or its equivalent, in any other form of vulcanizer.

**285. What is a vulcanizer?** Simply a heating device which will melt the new rubber into the old, so to speak. Rubber will unite if a small amount of sulphur be present and it is heated for a considerable length of time under some pressure.

**286. Is its use advisable?** Yes, at all times. Every motorist should possess one, know how and when to use it, and carry it with him at all times. Self-curing patches and cements may be correct in theory, but a motorist can never be sure of himself when he has one or more of them. With a vulcanized job he is safe, and knows it.

**287. In vulcanizing, is it possible to damage the tire?** Yes, indeed; the rubber may be heated too hot or kept at a high temperature for too long a time. The former is done usually when the repairman is limited for time; sooner than do a good job and make you wait for it, he will use a higher pressure and temperature than he ought and force out the job more quickly.

part, at least, is to inflate it slightly as soon as it is in place all around. This air pressure inside throws the greater portion of its bulk up against the top of the shoe and out of the way of the bead where the work is being done. Care must be taken not to overinflate, however, as this holds the casing in a stiff, inflexible position, and makes forcing it on more difficult.

In defense of the clincher rim and tire, which are going out of use very rapidly, being used only on the very cheapest cars, and on very few of those, it should be said that it was a simple form, had a minimum number of parts, the lightest possible weight, and cost the least money. As soon as the rim is split so as to allow of putting this kind of tire in place without stretching the bead, at least two pieces are added to each one of the four wheels, adding weight and cost.

**Q D CLINCHER TIRES** and rims follow the old-time clincher in simplicity, low first cost, and small number of parts. These are, as the name indicates, clincher tires which are quick detachable. This is effected by the introduction of a locking ring to hold in place the outer and removable half of the former clincher rim. The latter is split into a fixed member which carries the inner lip, a flat central portion across which the tire can be moved, and a depression or channel around the outside which forms a resting place for the locking ring. The outer lip is formed by a one-piece, circular ring, which has an inside shape similar to the inner lip and a straight outer side. The locking ring is made to force in between the channel and the lower corner of the outer lip member, and carries at one end a round lug, projecting downward at right angles to the inside of the ring. In the channel, there is a hole into which this lug fits tightly, this forming the starting place for putting on and the finishing point for taking off the locking ring. The balance of the ring is simply sprung into place, its natural spring holding it firmly, while the manner in which it is put in place, along a diagonal line, combined with the fact that it must be removed in the same manner, while all stresses exerted on it in running are either straight outward or straight upward, making it preëminently safe. When the tire is inflated, the outside lip portion is forced outward against the locking ring, so that it is impossible to remove the latter.

**REMOVING TIRES.** In order to take off a tire, the air is let out, and as soon as the tire in deflated sufficiently, with a hammer the outside lip portion is loosened and forced in against the tire. This makes it possible to pry out with a screwdriver, tire tool, or other sharp-pointed instrument the free end of the locking ring. When the outer lip portion of the rim is forced in sufficiently to allow of this being pried straight up so the operator can get his tool under it and over the edge of both channel and outer lip portion, he proceeds to go around the wheel, prying up the ring as he goes. Usually it is necessary to force the lip portion in with another tool or hammer as he goes along, in order to free the inner edge of the locking ring as the work progresses. When the operator gets around to the end of the ring, he lifts the lug out of the hole in the channel, and the ring comes free of the wheel. Then the outer lip portion can be lifted off readily and without the use of force. Next

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**288. In what way is this manifest?** The rubber becomes brittle and, when badly worn or on the sides of the tread wherever there is a crack, pieces of it may be broken off in distinction to a good tire from which it is necessary to pull the piece by main force, or perhaps cut it off.

**289. After a tire repair on the inside of the shoe, the piece set in did not stick?** Probably the fabric was wet when the repair was made. Inside shoe repairs should never be made until the fabric is thoroughly dried out.

**290. After a repairman had set a piece into a very large-sized tire casing, trouble and heating was experienced on the inside?** Probably the repairman did not vulcanize this on the inside, so that the job was only half done. On all repairs to large cases, it is impossible to vulcanize through, and failure will surely follow unless the job is vulcanized both inside and outside.

**291. A tire case was retreaded and then carried as a spare. When put into use, it lasted but a short distance, not over 50 miles?** A retread job should be put into use immediately. There is something about retreading which makes the tire deteriorate much faster than a new one, and, if held for an emergency, it may be found wanting.

**292. What mileage should retreading give?** This depends entirely upon the condition of the casing, the quality of the rubber used for the new tread, the care with which it is ap-

the outer bead part of the tire casing is pried out all the way around to some such position as shown at *B*, Fig. 119, *A* showing the removal of the ring.

Now, it is possible to reach in and loosen up the valve, lifting it up inside the shoe, until it comes entirely out of the hole through the rim and may be pulled out of the tire. With the valve portion out, it is a simple matter to go around the wheel, lifting out the tube. This done, the trouble may be fixed, unless it happens to be concerned with the shoe. In that case, the latter is pulled directly outward across the flat portion of the rim, and lifted off bodily. Replacing the tire after fixing the trouble, or when new, is just the opposite of this; first, the inner bead is put in place, then the inner tube, followed by slight inflation to take it up out of the way, then the outer bead and the outer ring following it is forced into place, forcing it in particularly far at the hole in the channel so as to put the lug of the locking ring into place; then it is forced in all around, the ring at the same time being sprung, forced or driven down into the channel and against the sharp lower edge of the outer ring, until the circuit of the wheel is

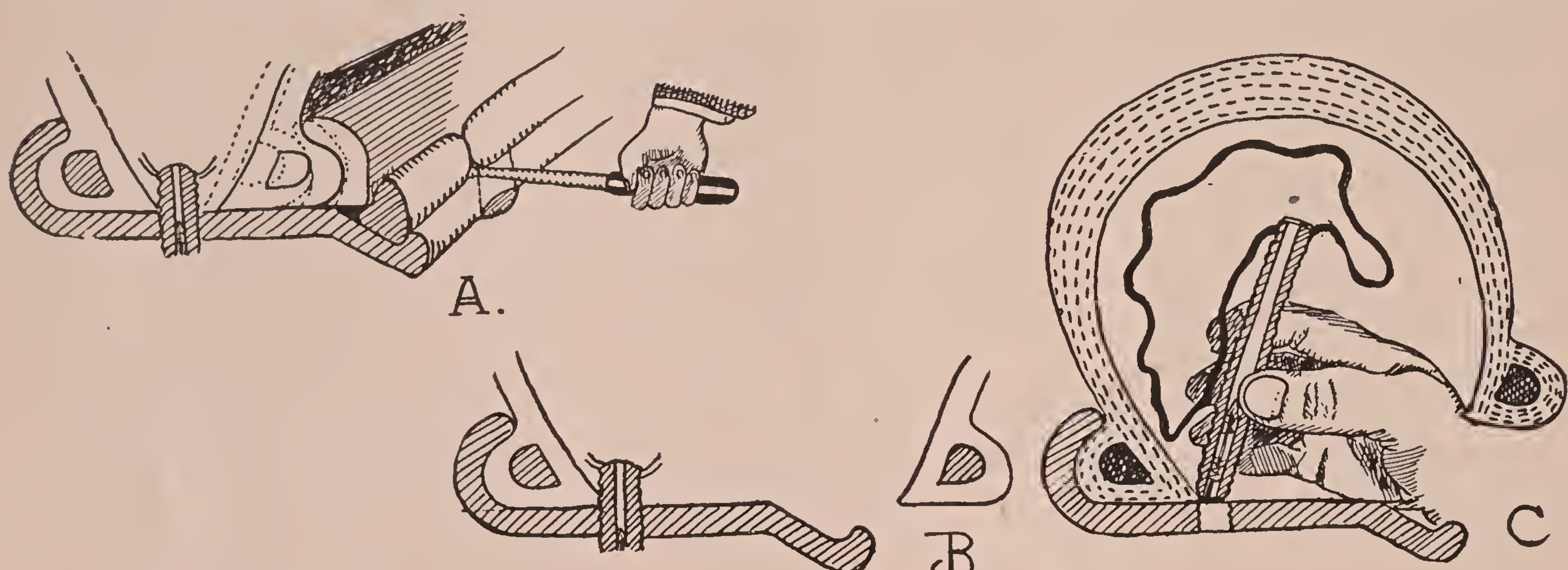


Fig. 119.—Taking off a Quick-Detachable Clincher Is Much Easier. First, the Locking Ring Is Pried Out as at A, after Which This Is Loosened all Around and Removed Bodily. This Allows of Taking off the Outer Ring of the Rim Proper. Then the Tire Outer Edge May Be Pulled Straight Out, as Shown at B. This Leaves Room to Insert the Hand and Take the Tire Valve Out of Its Hole, When the Inner Tube Can Be Taken Out.

completed and the end of the locking ring snaps into place. Then it is well to go around the locking ring and outer ring lightly with a hammer, to make sure that both are in exact positions. This done, the tire is inflated, stopping when about half through to go around the two rings with the hammer again in order to insure both of them being absolutely right.

Although the tires for a plain clincher and a Q D clincher look alike, they are not; the bead on the one, as has been pointed out, is flexible and can be stretched; on the other, it is made as strong and stiff as possible, and cannot be stretched. However, the plain clincher type of tire may be used with safety on a Q D rim, although the reverse is not true—it would not be possible to put the tire on.

A form of tire, formerly popular, and now coming back into favor, is the straight side, or Dunlop. This is used with the same type of rim as the Q D

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plied, and the use to which the tire is put after retreading. In general, it does not pay to retread unless the owner can see or be convinced that the job will give him about a mile for every cent expended; that is, 1,000 miles for a $10 tread, 1,200 for a $12, 1,500 for a $15 job, etc.

**293. A tire was put into use with a new tube in a new casing, put on by the dealer. It began to leak at 250 miles, and at 300 was leaking very badly?** Probably the interior of the shoe was moist, and the dealer, in putting on the new tire, put in too much chalk or soapstone. The moisture and pressure combined to form this excess into a number of small balls, but very hard. These were pressed into the soft rubber tube by the air pressure, until they wore practically through it. As soon as they did, the tube began to leak. The amateur should be very careful in filling up a casing with chalk or talc; an excess serves no good purpose.

**294. In taking off a tire, it sticks to the rim?** Either it has rusted on, or else it is an unusually tight fit at a point where the metal has rusted or has a rough surface. Use a hammer freely to start it, but hammer only at the point where the tire sticks, and do not use the hammer more than is necessary, nor after it has started to come off.

**295. In taking off a tire, the locking ring of the quick-detachable sticks in the groove?** Make sure the free end has been pried loose, then drive the flange against the tire, using

clincher, with this exception The lip on the inside of the rim has a filler piece of more or less hard rubber placed in it, this having a straight inner edge for the base of the tire to rest against. In addition, the outer ring is turned over so that it presents the straight edge formerly on the outside to the fire. In this case, the long, sharp edge which formerly projected under the base of the outer bead is turned outward and the locking ring rests against it, holding the member up against the tire as before. The method of putting on or taking off a tire is the same as before. Since this form of tire has nothing to hold it in side direction. other than the pressure within forcing it against the filler strip and the inverted outer ring, it is customary to make this kind of tire with a number of fine metal wires incorporated in the two lower parts of the base which correspond with the beads of the other forms. This makes that part of the tire more stiff and opposes any tendency to stretch. In Fig. 120, *A* indicates the Q D rim with a clincher tire in place; *B*, the same rim with a straight side and the outer ring inverted, while *C* shows another straight-sided or Dunlop form, with a special rim made for this purpose. The rim shown in *A* and *B* is known as the Standard Universal No. 2.

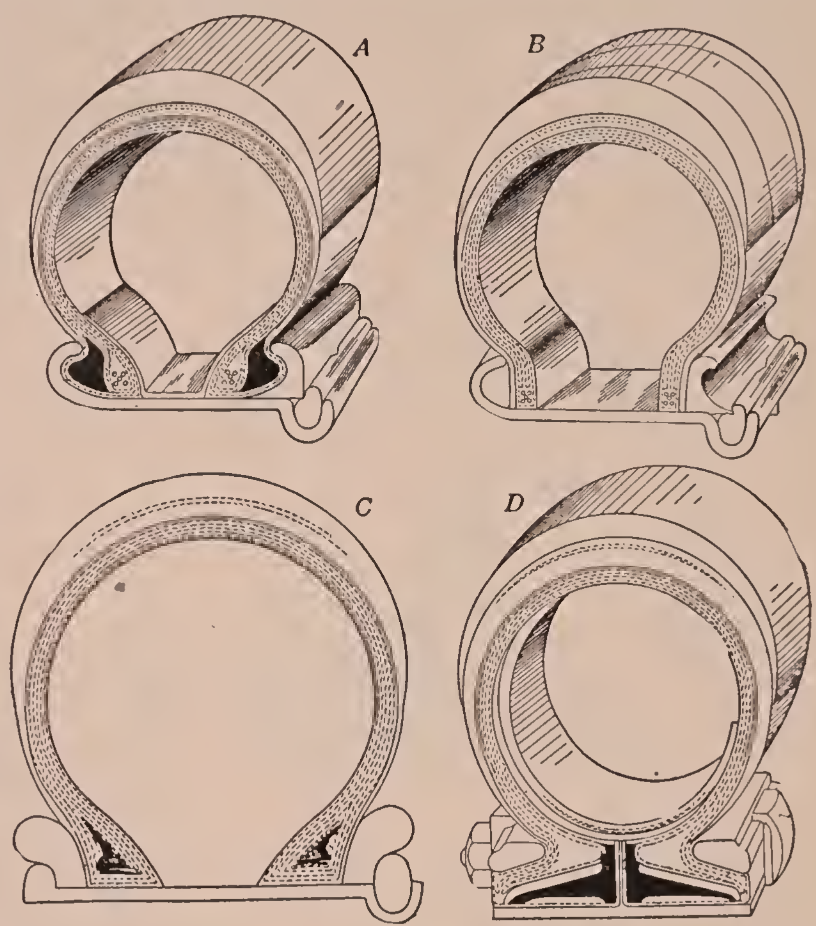

Fig. 120.—Four Typical Tire and Rim Forms. At A, the Q-D Clincher, Illustrated Previously in Fig. 119; at B, the Same Rim Fitted up for a Straight Side of Dunlop Tire; at C, the Goodyear Special Dunlop Form with Special Rim; at D, the Fisk Bolted-On Type of Quickly Removable Tire.

This shown in *C* is also universal, in that the two loose rings, inside and outside, may be turned over, when the rim will hold a regular clincher or Q D clincher tire. The form seen at *D* is one which has been developed by a tire company, and requires a special wheel. The bead portion of the casing is made with a perfectly flat base. This is divided in a vertical line, the two halves meeting squarely, face to face. The outer portion of this lower part of the tire has a sloping surface, upon which a pair of rings are forced, one on the inside and one on the outside. Through the rim, just below the iron band upon which the base of the tire rests, there are a series of 12 holes, equally spaced around the circumference. A series of bolts pass through these, having a head on the one side which projects up far enough to rest on a groove on the one ring, while a kind of washer, also of such a size and shape as to reach to the groove on the other ring, is used on the other side, with a nut to tighten the same. By means of a special clamp, which the makers furnish, the two sides of the tire are drawn tightly together, when the nuts are screwed up as much as possible. Since the nuts and bolts hold the rings firmly in position, and since the tire cannot move

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a heavy hammer. It may be possible to pry this back and hold it, depending upon the tools available, while a small chisel is placed under the free end of the ring to start it out. As soon as this has been forced out so that it stands above the flange, something should be placed underneath it so that it cannot slip back. After this, it is a simple matter of continuing around the circumference, alternately prying the flange and tire inward, and then the locking ring upward. If this proves very stiff and springy, keep something beneath it all around, moving this along as the work progresses, so there will be no possible chance for this to snap back into place, and make it necessary to do all the work over again.

**296. In taking off a demountable rim, the threads on one or two bolts are found to be defective?** The ring has got to come off, so it will be necessary to make new threads or improve the battered ones enough to allow forcing the nuts off. With a cold chisel held squarely at right angles to the threads, drive between each pair of the damaged ones, going around the bolt gradually in the spiral and of the direction which the space at the bottom of the threads formerly formed. After this has been done once or twice, by means of a little lubricant the nut can be started Screw this off as far as possible, but if it cannot be taken off entirely, screw back again far enough to allow of working on the threads. Repeat the work, and then force the nut off.

until the rings are lifted off of their lateral projections at the base, this forms a very firm method of holding the tire on. By removing the 12 nuts, the ring on the outside can be lifted off, when the outer side of the tire can be pulled out and the tube removed.

**DEMOUNTABLE RIMS** are so made that the tire may be removed from the wheel, complete with tire and all. This allows of carrying an extra tire in place on an extra rim, inflated and ready for use. In case of puncture, blowout or other trouble, the wheel is jacked up, the offending tire removed with its rim and the extra tire and rim put in their place. This arrangement minimizes the delay, and does away with the labor of pumping up tires on the road. There are almost as many styles of demountable rims as there are tires, practically every large tire company having a form which it advocates, while there is a considerable number of them which have been placed on the market directly by their inventors.

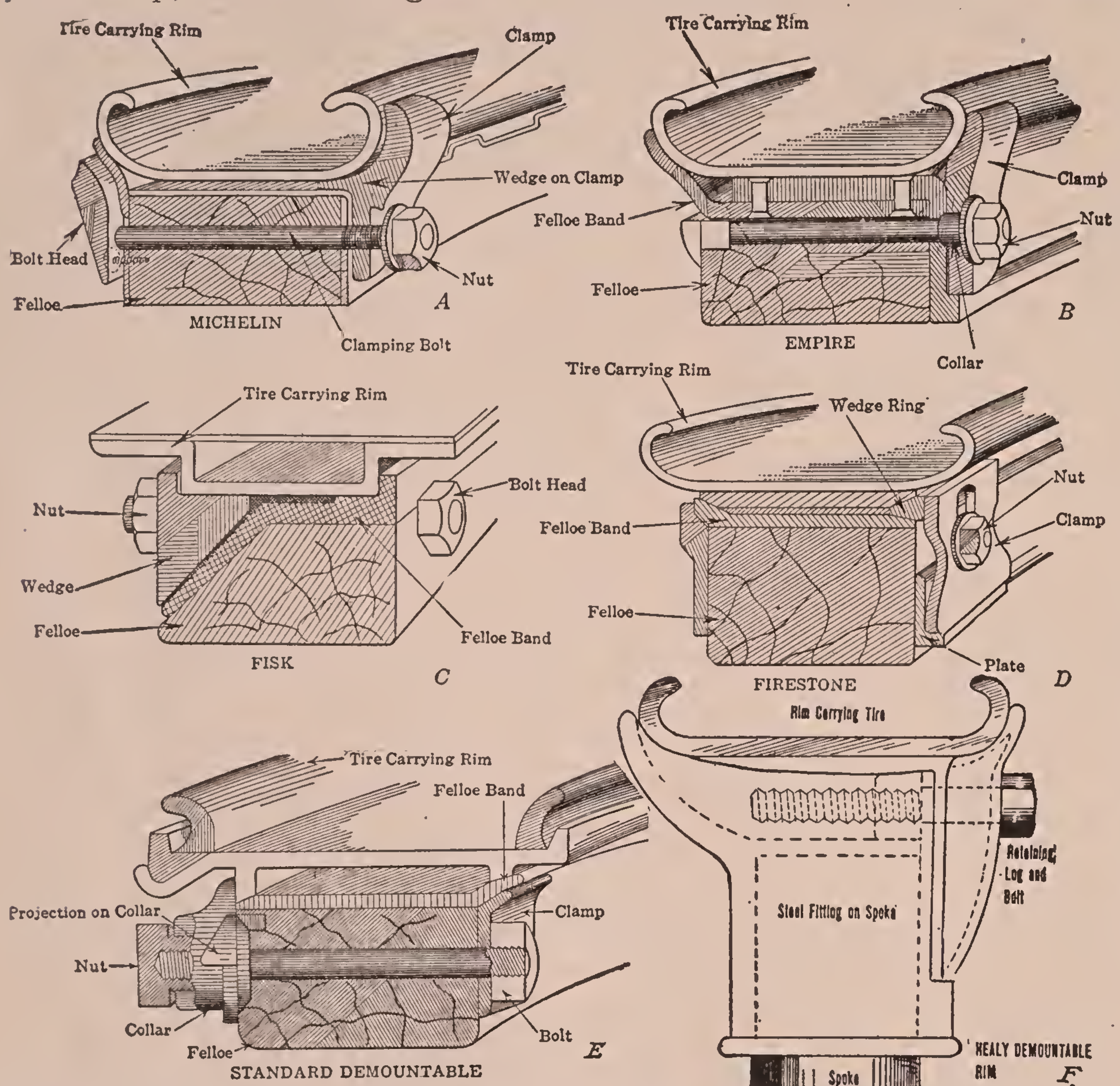


Fig. 121.—Some American Demountable Rim Forms Now in Everyday Use. At A, the Michelin; at B, Empire; at C, Fisk; at D, Firestone; at E, Standard, and at F, Healy.

In general, the construction includes a false rim upon which the rim carrying the tire is forced and held by means of wedges, clamps, or other fastening means. Fig. 121 shows five of the common forms. The one seen at *A* is the Michelin, in which a series of clamps around the circumference of the wheel carries wedges which not only push the tire-carrying rim in tightly against the stop on the other side, but also push it outward in a radial direction so that it is held more firmly. The bolts are set into the wheel permanently, and only the nuts are removed. As

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**297. Will this spoil the rim for future use?** Probably not; the action of the nut, working over the threads, will cut them nearly right where the chisel failed to give the right shape. Doubtless the nut will go right back on, and the rim will be as good as new.

**298. Can a clincher tire be used with a Q D rim?** Yes; but the greatest of care should be used in putting on the flanges and locking ring, in order to make sure that everything is tight. It must be remembered that the clincher form has a semi-flexible bead. For this reason, it should be held in place more tightly and more accurately than a Q D.

**299. Can a Q D tire be used on a clincher rim?** No; it will be impossible to stretch the stiff and strong beads of the Q D form over the clincher rim.

**300. Do non-skid treads on tire eliminate skidding?** Not entirely; but they help a great deal. If the conditions are right for skidding, nothing will act as an absolute preventative. Tire chains are very good, non-skid treads are good, studded tires are good, but none of them can be classed as perfect.

**301. What is the difficulty in wood wheel manufacture?** The material suitable for this purpose is giving out very rapidly. Second-growth hickory is supposed to be the best, but more than half the wheels to-day are of ash, or a combination of ash and hickory. Makers are turning to the wire form for this reason.

**302. What other advantages are supposed to go with the wire wheel as compared with those of wood?** It is lighter by more than 25 per cent., so that five wire wheels with their

soon as these have been taken off or loosened sufficiently, the clamp with the wedg can be pulled out and by turning it around, the wedge portion hangs downward out of the way. When this has been done to all of them, the tire carrying rim will be free in a lateral direction and also loose in a radial direction.

The form seen at *B* is the Empire, in which the false rim on the wheel is built up with a filler plate so that the rim is a tight fit upon it. The bolts are set into the wheel permanently, as before, while the clamp is used as a clamp only, and not as a wedge. In a Fisk form, seen at *C*, the false rim is made with a peculiar shape, one edge being cut away so as to form a long diagonal. Into this the clamp, which has a triangular shape, is forced, thus forming a wedge which tightens the grip on the tire-carrying rim as the nuts are tightened. In addition, the base of the tire rim is made with a rectangular projection, while a groove is milled in both the false rim or felloe band and the wedges. By screwing up on the nuts until all three of these parts are wedged tightly together, the tire rim is held tightly in a lateral direction. The Firestone form is shown at *D*. This has a false rim or felloe band on the wheel which is made with a tapered surface at either side. Resting on this is a filler piece which has a tapered surface to match on both edges of the bottom side. One of these fits against the taper on the inside of the felloe band, while the other is opposite to the one on the outside. In the latter opening a loose, wedge-shaped ring is placed and forced home by means of the flat clamps. These are made with an eccentric slot so that as soon as the nut is loosened sufficiently, the clamp can drop down out of the way of the wedge ring. Thus it is possible to take the rim and tire off without taking off any of the nuts or clamps, by simply loosening all of them.

The form shown at *E* is the Standard demountable. This has the tire-carrying rim made with a pair of projections on the underside, both of which are faced off to form wedges. The false rim on the wheel has a pair of tapered surfaces to match these, and the arrangement of the collar or clamp is such that the nut pushes the tire rim inward as far as it is supposed to go. A metal collar set into the wood of the felloe around each of the bolts prevents this from being carried too far. In the form of rim seen at *F*—the Healy—the end of each spoke is fitted with a special round metal casting which has a round slot milled in one side at the top. It is threaded for a bolt also. The inner edge of each of these is turned up to form a stop for the inside of the tire rim. The latter is put in place, then the bolts with their retaining lugs are each put in place and screwed home. This locks the tire rim tightly in place. This form is a very simple one, having fewer parts than any other on the market, but is open to this objection: That as the felloe of the wheel is removed entirely, the wheel is weakened materially; in fact, the car is running at all times on the tire-carrying rim. It is widely used by the taxicab companies.

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**SOLID TIRES** are of wide interest to the business man, for all of his motor trucks, unless they be very light in weight, are equipped with them. Like pneumatics, these come in a great variety of forms. As they have attained their present form *after* the pneumatics, the makers were able to take advantage of mistakes made in the early days of the latter. Conse-

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tires do not weigh any more than four of wood; it is stronger to resist side stresses, as sliding against a curb in a skid; it is much more resilient; it keeps the tires cooler, for the reason that the metal felloe can radiate any heat very quickly, while wood cannot. This reduces the amount of tire trouble; its general form and light weight lend themselves readily to the detachable wheel idea. This makes it possible to change the whole wheel and tire as quickly or more quickly than the wheel and rim in the case of demountable rims, or the tire alone in the case of Q D tires.

**303. In general, are wire wheels made in the same sizes as wood?** No; as mentioned previously under tires, wire wheels generally are made to take tires of smaller diameter but larger cross section than is the case with wood.

**304. What is the advantage of this?** The tire costs are about equal. For instance, a 36 x 4 will carry safely on a front wheel 900 pounds. A 32 x 4½, four inches smaller in diameter but ½ inch larger in cross section, will carry with safety 950 in the same place. The latter will cost just a little bit less than the former. This change, if it were forced by a change to wire wheels, would lower the car by a full two inches, bringing the center of gravity that much lower and making the car correspondingly much safer to drive. It would hold the road better at speed, take corners better, and with the driving gears

quently, we find all solids removable from their wheels. In general, solid tires are made with some metal incorporated in the base. Formerly this consisted of a series of wires, running around the base of the tire, or of a wire mesh or screen, several folds of which were incorporated in the base portion. The latter has been abandoned to a large extent, while the former has been modified by the addition of short cross wires. The better known products of the large companies, however, have a fairly thick metal ring for the base portion, to which is vulcanized a fairly hard rubber, somewhat like vulcanite. Above this comes a softer material, while the tread portion may be a more or less hard composition, or a fairly pure and somewhat soft rubber.

Whichever construction is used, the metal base may be redeemed at the tire company's office, an allowance being made for this on the new tire purchased in its stead. Usually, however, it is not possible to wear the rubber right down to the metal base because of the attaching flanges which project above this. Some solid tire forms seen in Fig. 122 show both the tire construction and the attachments to wheels very plainly. In this, the forms at the left represent sections through typical single tires, while those at the right are all of the dual form.

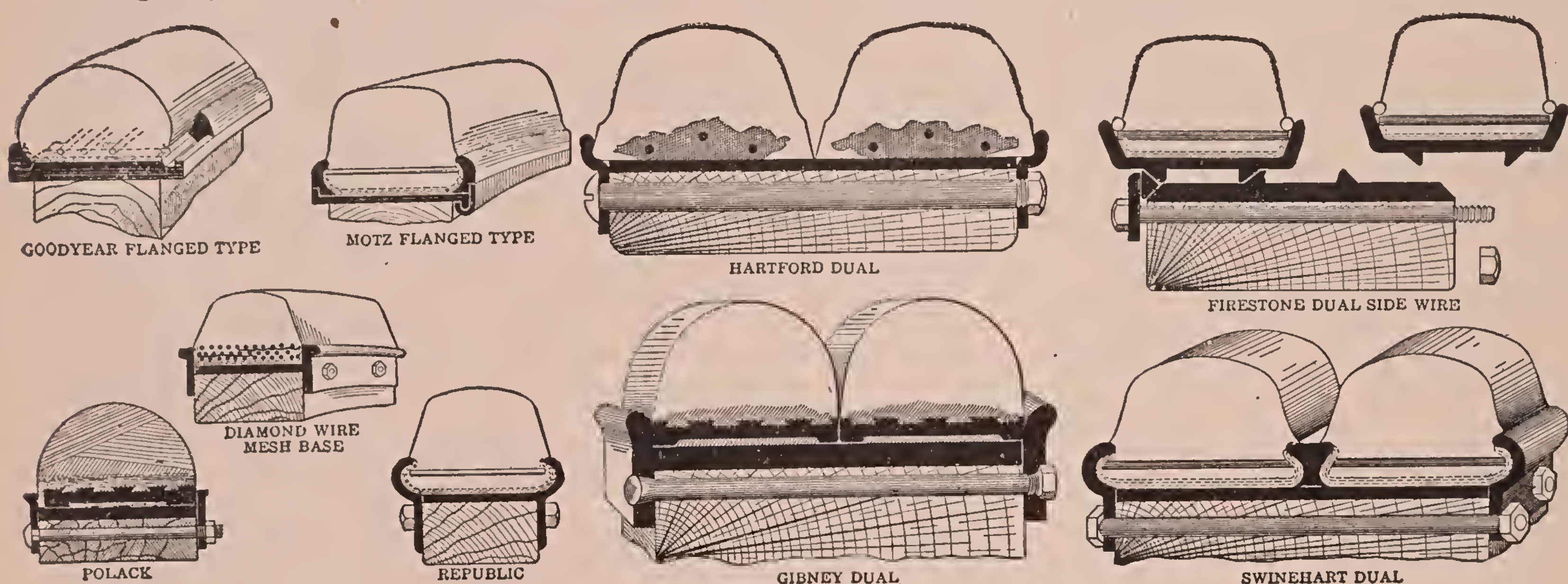


Fig. 122.—The Typical American Forms of Solid Tires in Single and Dual Types. All These Are Named so That It Is an Easy Matter to Pick Out Any Particular One. The Sketches Show Cross Sections, the Solid Black Parts Indicating Solid Metal.

The first form shows one which is pressed into place and then held by means of a ring which fits down into a groove cut in the extra felloe band. The ends of this are held by means of screws. The second form has a form somewhat similar to a Q D rim for pneumatics, this consisting of a ring which fits tightly against the tire and having a square groove in its lower corner. The felloe band carries a downward projecting lip which is semicircular in shape. A locking ring which fits into both of these is used, this being sprung into place. Its natural spring tends to force it outward, and it can be loosened by pulling it inward. Consequently, when once sprung in place, it holds tightly.

The next three forms are alike as to fastening methods, although differing slightly in details. In all these, the tire is pressed on against a stationary flange on one side, after which another flanged ring is put on the outside and pulled up tightly by means of a series of through bolts. In the case of the first one, both

changed to compensate for the loss of speed the whole car would act better. Who ever heard of a racing car with tires of large diameter?

**305. Is it advisable to buy oversize tires?** For city use, no; but for country work and long-distance driving, emphatically yes. Every cent spent on the larger sizes will come back to the driver with interest in the latter case.

**306. Why do oversize tires not pay on city streets?** The tires are worn out by the streets and the material on them, car tracks, etc., by cutting on tracks along the treads or rubbing along the sides, by unusual wear due to frequent stopping and starting; in short, by conditions which have little to do with the normal wear and natural mileage possible in the country. Under such circumstances, the small tire has been found to give as great a mileage as the oversize.

**307. Is there much danger from overinflation of tires?** Very little, except in the very hottest weather, according to the tire people. In actual practice, much more comfort is obtained with little departure from the expected mileage by keeping the tire pressure just a few pounds—say, not over 5—below the maker's recommendations.

flanges have curved portions which fit around a similar curved part of the tire, while the second and third have fairly stiff projecting lips which guard the tires against shocks from the sides.

In the dual forms, it will be noted that similar arrangements of the tire base, felloe bands and rings are used, except in the case of the Firestone dual. In this the demountable idea is carried out, and provision made for removing the tire more quickly and easily than in the other instances, in many of which a special press is needed to put on or take off a tire. In this one, the underside of the tire-carrying rim has a pair of projections which are tapered to match a pair of tapered seats formed on the special felloe band. One tire is put on from the outside, the other from the inside, both being wedged into place by means of outer wedging rings, which in turn are forced up to place by means of stout flat bands. The nuts act against the latter. In order to remove an inside tire without touching the outer one, it is only necessary to take off the nuts from all the bolts, and then drive the bolts out, so that the inner locking band can be removed. This lets the wedging ring drop off and permits the removal of the inside tire. The process of taking off the outside member is exactly the same, except that it is not necessary to drive the bolts out, simply removing the nuts. Some makers space the dual tires apart by means of a filler piece; others allow them to come right up against one another. In defense of the latter course, it is held that stones or other foreign material are not as likely to wedge in the space between the tires on account of its being very small. Consequently, it gradually fills up with dirt, and then there is no possibility of stones, bolts or nuts wedging in there. With the tires separated one-half inch or more, there is formed a considerable opening, and good-sized stones, as well as pieces of wood, iron, etc., get wedged in there and cause trouble.

On the other hand, the widely separated tires of equal size present a wider base, and as a result a more stable one. This additional width is an advantage on poor roads, and where the wheel tends to dig in soft ground, the digging tendency would be resisted better. Under the stress of heavy or fast work, solid tires heat up considerably, and this is very destructive. The more widely separated duals would have a better opportunity to cool off, as the space between them will allow of better radiation of the heat. Where the tires are set close together, the weight of the load flattens the surface rubber down until the sides of the two meet and present practically a flat surface of rubber to the road, slightly wider than the base of the two tires. When they are more widely separated, the flattening action is greater, as each one has more freedom on the sides. In this way, a greater surface is presented to the road, and the total wear is greater.

Practically all heavy trucks present single solid tires in the front and duals in the rear. On lighter wagons, up to as high as 3,000 pounds' load, it is customary to use solids in the rear and pneumatics in front. Another practice which is becoming quite common on cars of this size is to use dual pneumatics in the rear and single pneumatics in the front. By making these of the same size, the car uses six tires all on one side. Buying these all at one time, a slight economy is effected in that a somewhat better price can be had. In addition, all tires are interchangeable.

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**308. Is there much danger from underinflation?** Yes; it is said that almost half of tire troubles come from serious underinflation. This causes rim cutting, which ruins a tire and which cannot be fixed, even before the tread has begun to show signs of wear. It causes a loosening of the tread all around, giving it a wavy appearance. This may or may not be repaired by retreading, according to the condition of the balance of the tire. If a tire is kept up nice and round, there will be little danger from either under or overinflation.

**309. Do tire chains put on to stop skidding injure a tire?** Not very much, if applied properly and according to directions. They should be allowed to float or move around the wheel, for if fixed in one place they will start to cut, and if kept on for any length of time, will go right through the tread rubber wherever there is a cross link.

**310. Do extra tire treads put on over the tire to stop skidding and give greater mileage injure a tire?** Not if put on properly in the first place. If put on so that there is nothing to rub or chafe, no heating will occur, and this is the greatest, perhaps the only, source of trouble with these. Generally, when new, they are so stiff that the amateur driver is willing to let them go any near the right place. This is a serious mistake, and will lead to heating, possibly cutting and other troubles.

**WHEELS** are of wood generally, although the steel wire form is coming into use very rapidly, and the season of 1914 saw perhaps one-tenth of the new cars so equipped, while 1915 will doubtless see at least one-third of the new vehicles and practically all of the higher ones so fitted. This is an unusual situation, for in the beginning the majority of cars were made with wire wheels, which went out of use very gradually. These were, however, bicycle wheels, and as cars became heavier and larger in every way they could not do the work satisfactorily. With their practical abandonment by the automobile industry, wire wheel builders began to improve their product, with the result that they have produced a different form which is admittedly superior to wood in every way. This being the case, it is but a question of time until public prejudice against them is removed, when they will become well-nigh universal.

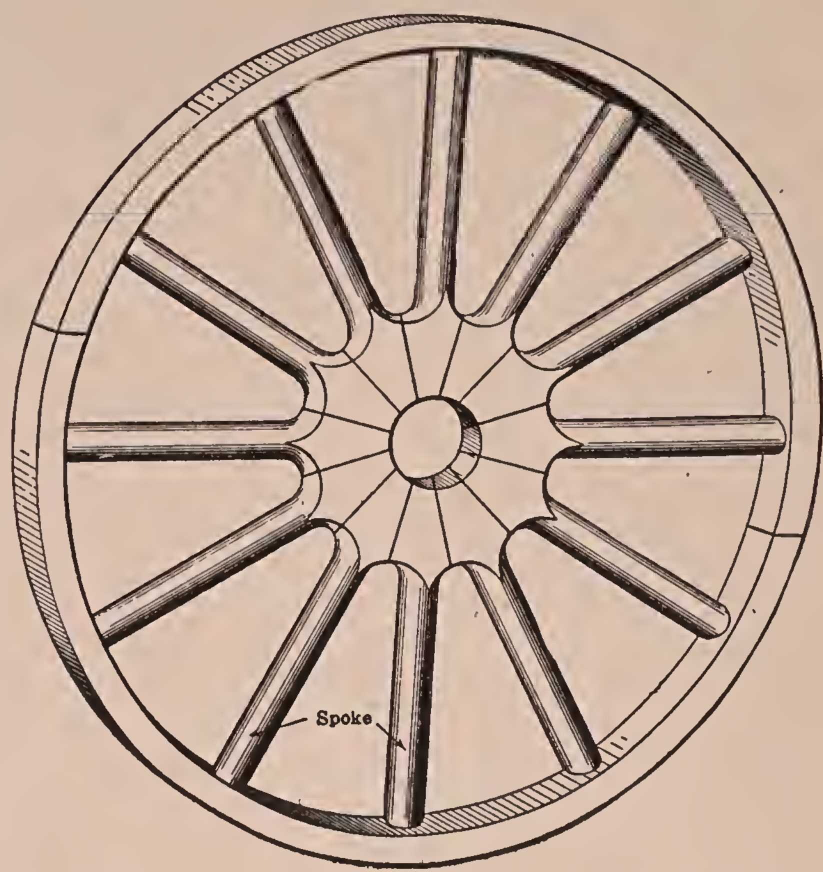


Fig. 123.—Typical American Artillery Type of Wood Wheel, as Used for Motor Cars, Shown Before the Band Is Shrunk on the Outer Circumference or the Hub or Hub Flange Bolted in Place.

The first wood wheels were of the so-called Sarven type, adopted from carriage and wagon building, but from this was developed the artillery form in which the inner ends of the spokes formed a series of wedges which completed a flat but very strong construction to which the hubs could be bolted. One of these is shown in Fig. 123, this bringing out clearly the construction. Each spoke is formed with an oval section up to its extreme end which has a round portion to fit into a hole bored in the flat, curving sections forming the felloe. The inner ends have a flat shape from one side and that of a wedge from the other, so that when the wheel is assembled the 8, 10 or 12 spokes, as the case may be, form a complete circle there.

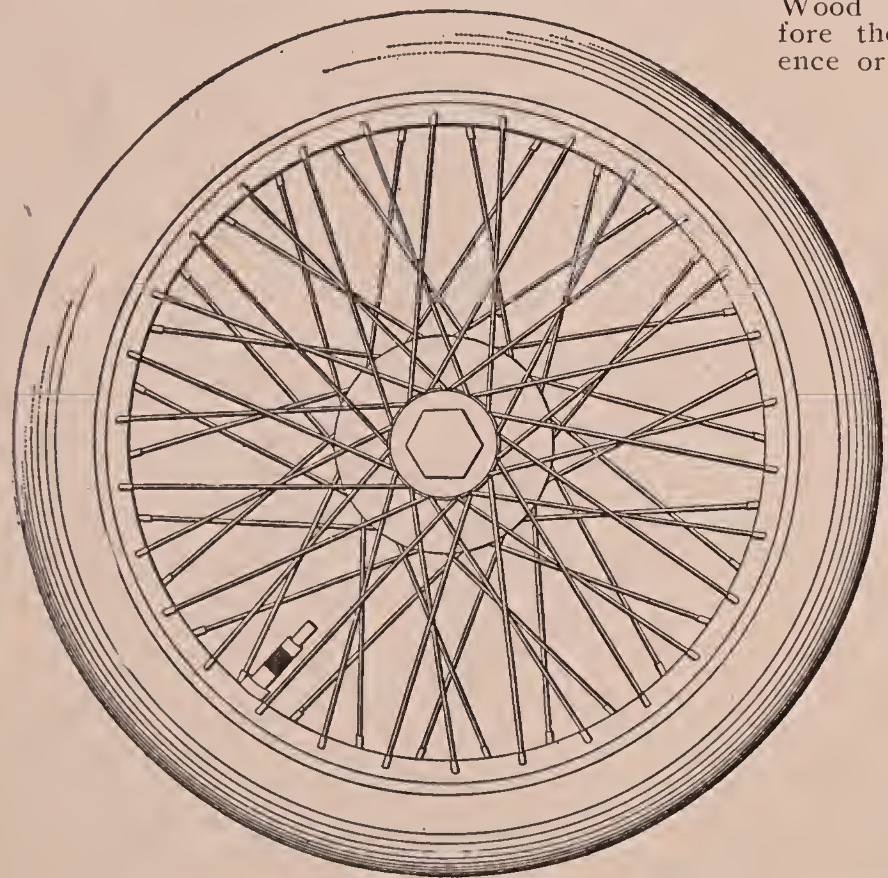

Fig. 124.—A General View of a Wire Wheel, Showing How the Spokes Radiate from the Inner, Outer, and Center Portions of the Hub and Flange.

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**282A. What is the advantage of using these treads?** The tire can be used until perhaps two-thirds of its normal mileage has been gotten, then by putting on the steel-studded leather cover, which costs less than one-half a new tire, an additional 5,000 to 6,000 miles may be obtained. This is said with the proviso that the old tire is in good condition throughout except for the natural wear on the tread which has taken place. An additional point is that the steel-studded leather cover is puncture proof, so that while using it, the motorist can forget the ordinarily troublesome puncture.

**283A. If the car is put up for the winter, is it advisable to do anything with the tires?** Yes, the best plan is to release the air, not all, but leave just enough to keep the tubes fairly rounded out, if the tires are to be left on the wheels. A better plan is to take the tires off entirely, deflate the tubes altogether and roll them up, and put away in a pasteboard box, in much the same manner as they come. Then wash the casing clean, allow it to dry, and then cover all over, winding with the paper tire makers use, or with any substitute. Then hang them in any cool, dark, dry place.

**284A. Why must tires not in use be kept in a cool, dark, dry place?** Because the three greatest enemies of rubber and those which will cause it to deteriorate most rapidly are light, preferably sunlight, heat and dampness. Naturally one does not get all

The central hole is for the hub, while the extremity of the flat portion marks the outside size of the hub flange. A steel band is shrunk on the outside, thus binding the whole wheel together firmly. Attention has been called to this previously.

In one certain make of wheel, instead of a flat side for the wedge-shaped ends of the spokes, these are tongued and grooved, the tongue of one fitting into the groove of the next. In this way lateral stability and strength was given to the wheel at a point where they were most needed.

It is due to this very lack of lateral strength that the wire wheel is making such rapid progress. In a sideways direction, the wood wheel is lamentably weak, while the frail-looking wire form has been found to be many times as strong. Moreover, as soon as the wooden form has been struck several blows, the wheel begins to part so that but a few more blows are necessary in order to render it unfit for use. With the wire form, on the other hand, it has been found that after as many blows as will break a wood wheel apart, the wheel, though badly bent, is still strong, and may be used.

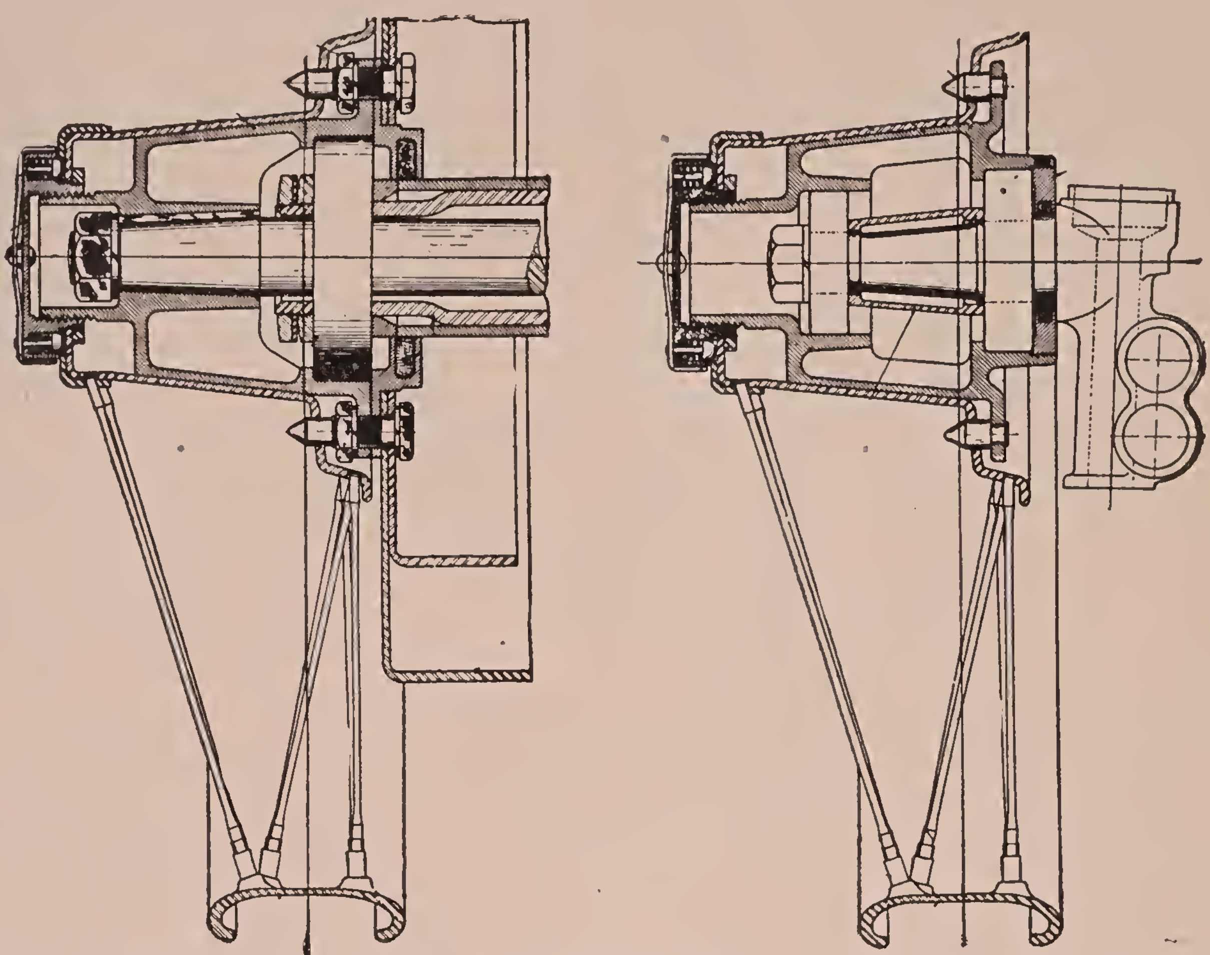

Fig. 125.—Sectional View of McCue Triple-Spoke American-Built Wire Wheel. At the Left, a Rear Hub; at the Right, a Front Hub. Note How the Triangular Arrangement of the Spokes Makes a Stronger Construction.

In vertical strength, the wire form is not only stronger, but is much more resilient, so that a car equipped in this manner rides more easily than with wood wheels. Its greatest feature, however, lies in its lighter weight. This is enough less so that five wire wheels—that is, the four on the car and a spare—do not weigh as much as the usual four wood wheels. At the present time, the cost of these is more than wood, but as soon as they are used in sufficient quantities to bring the price down, there is no doubt that their greater simplicity, cheaper material and other features will make them cheaper than wood, the raw material for which is more difficult to get and more expensive every year.

When this is brought about—wire wheels will have every possible advantage—greater strength, lighter weight, better riding qualities, easier on tires, and

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three at once, as a damp place would seldom be a warm one. Of the three, light is the worst; so, even if you do not do anything else to the tires when they are not in use, be sure to cover them thoroughly.

**285A. What can be done to the rim at the same time?** If the tires are removed, it is both a good opportunity and an excellent plan to paint the rims all over with some kind of rust-preventing paint. This should be put on in a thin coat, and, if after thorough drying, this does not seem thick enough another may be put on. If for any reason the owner does not wish to apply such paint, the rim should be coated with a graphite grease. This can be rubber on thoroughly, but when using in the spring as much of the grease as possible should be removed with a cloth before putting a tire on it.

**286A. Is it advisable to run on the rims in an emergency?** If the car is not too heavy and the distance short, over good road surfaces, the motorist can proceed very slowly, and without damaging anything. If the rim is of the Q. D. type, it will be necessary to remove the loose ring and the locking ring on the outside, as otherwise they would be lost. If this is done at all fast or carelessly, the rim will be spoiled and will necessitate a considerable expense and much trouble to repleace it.

**287A. What other precautions should be observed in a case of this kind?** It goes almost without saying that the casing and

cheaper. At present, the price and popular prejudice prevent their extensive use, but they are gaining very rapidly.

The form shown in Fig. 124 gives a good idea of their general appearance when viewed from the side. This, however, is a double-spoked form, which has been superseded quite generally by the triple-spoked type. The three rows of spokes are used in order to get greater strength and resilience. In addition to the features mentioned above, the form of the wheel lends itself well to the demountable feature. This is so closely interwoven with the wire wheel that the latter is generally thought of as demountable, when such is not the actual case. Fig. 125 shows a demountable of the latest type, while Fig. 126 gives a good idea of the

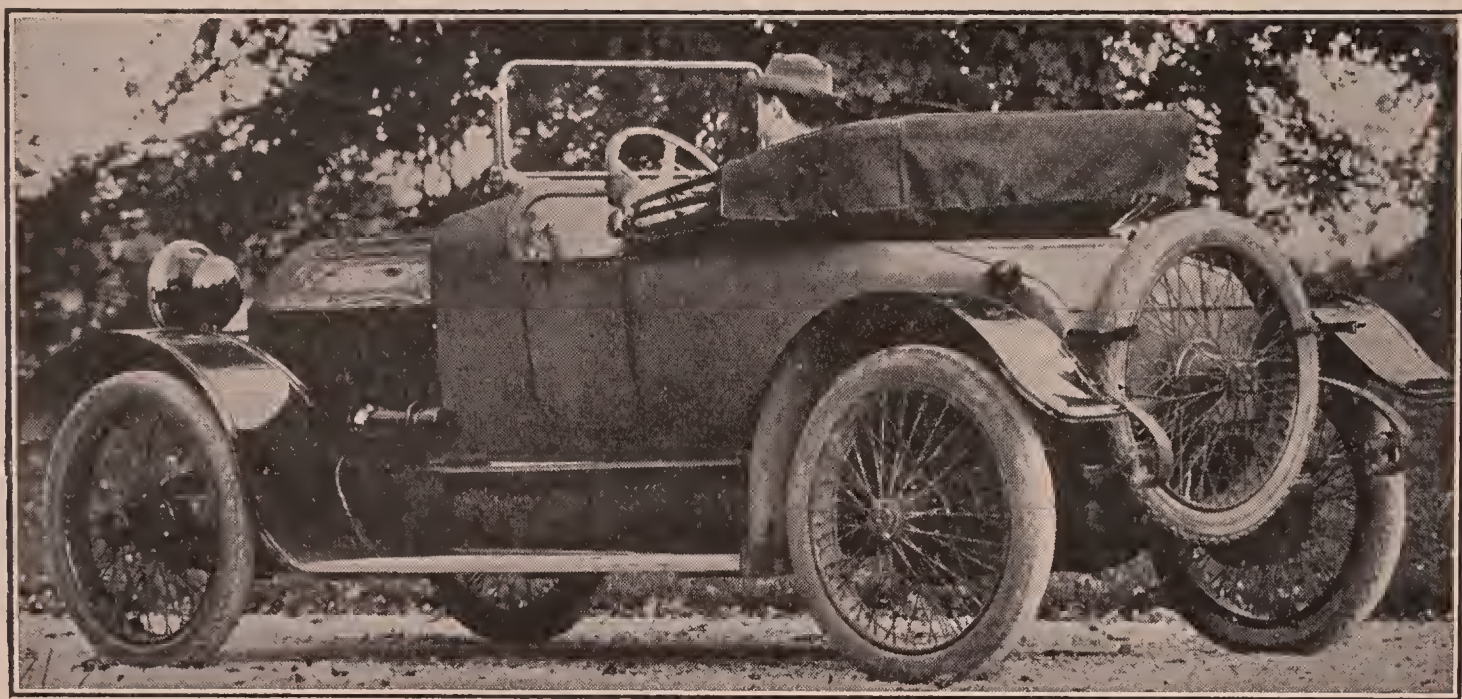

Fig. 126.—American Car of Moderate Price, Equipped with Wire Wheels. View Taken from the Rear to Show the Extra or Fifth Wheel as It Is Carried for Emergencies. The Five Weigh Less Than the Usual Four Wood Wheels.

excellent appearance of a car when equipped with wire wheels. In general, these are made in small diameters of wheel, but for large cross sections of tire. That is, the wire wheel has been developed for small diameters only, and none of these measuring 36, 38, 40 and 42 inches are marketed as yet. The equivalent of these large diameters, as to carrying capacity, is made up by using larger diameters. Thus, in place of 38 x 4, we would find a 34 x 5 or 5½ used. This makes for a lower-hung car, a positive advantage which car makers have been trying to get for many years, but the demand for bigger and bigger tires has caused them to go in the opposite direction.

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tube should be removed, as running any distance on them would cut both into pieces. A tube can be finished in less than 110 yards, while half a mile will just about finish a casing.

**288A. Is there anything that can be done in a case of this sort to make sure the rim will not be damaged?** If the motorist carries a tow rope, or can obtain any rope in the neighborhood, this can be wound tightly around the bare metal rim, and the end fastened with twine, wire or in some other manner. Then, if water be poured over the rope it will shrink enough to take a still tighter hold on the rim. It goes without saying that it should be wound around in the direction in which the wheel is traveling and not at right angles to it. In the latter, the rim would tend to cut each turn of the rope at every revolution. In the other way, there is no tendency to cut. If sufficient rope is available, the motorist can wind on enough so that it stands up higher than the edge of the rim, and thus, the latter will not touch the ground. Motorists have been known to run miles in this manner.

**289A. How would a person figure out how many turn of rope were needed, and what length?** Three and one-seventh times the diameter will give the circumference. The width of the rim divided by the size of the rope would give the number of turns which can be put on in one layer. This number of turns times the circumference would give the length needed for one layer. For two layers, double and add about 10 per cent. As an example: Suppose a wheel bare of its tire is 30 inches in diameter and 2½ inches wide. This gives a circumference of 3 1-7 times 30 or 94.3 inches, or say 8 feet. If the rope were 1 inch in diameter, three turns to a layer would be needed, and say two layers put on. This would be twice 8 feet plus 10 per cent., or say 17 feet.

**290A. How should solid tire be treated?** Just like pneumatics, with the single exception that they are not susceptible to punctures or blowouts. The rubber should have just as much thought and care; the fastenings should be looked after equally as well and just as frequently; small cuts and large ones should have the same attention. In general, rubber tires need about the same care whether they are made up into the pneumatic or the solid form. Any driver who goes on this assumption will have the lowest tire cost per mile travelled, and the least tire trouble.

# CHAPTER VIII.

## Gas and Electric Lighting and Starting.

**GAS LIGHTING.** Speaking broadly, gas for lighting has the prime advantage of simplicity and low cost, both first cost and maintenance. The chief disadvantage lies in the limited amount of gas which may be carried in the tanks used, and the inability of the makers to eliminate leakage when the system is not in use. The first disadantage has been minimized by appointing a tremendous number of dealers the country over as distributors for the tanks so that it is possible to exchange an empty tank for a filled one almost anywhere, at practically any garage. A decidedly minor point lay in the fact that the amount and character of the illumination was limited, but this was not brought out until the perfection of the electric system showed the possibilities of using 18, 20, and higher candlepower bulbs. In our larger cities, the use of these has brought forth anti-headlight ordinances.

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**ELECTRIC LIGHTING** is now considered a part of every car except the very cheapest forms, and even on those it is making rapid progress. Starting about 1909, it made little progress that year, but in 1910 a considerable number of the best makers declared for it, which number was greatly augmented in 1911. In that year, too, it began to make great advances among the medium-priced cars, while the development of the various systems, and the components of the same warranted the statement that it was an unqualified success. The next year, 1912, saw its adoption on the balance of the medium-grade vehicles and its adoption for all high-grade machines, together with a considerable number of low-priced cars. With the perfection of the various components came quantity production also, which in turn made much lower prices possible. This gradual evolution led to its still wider adoption in 1913 among the lowest-priced cars, which movement is continuing so that perhaps as high as 92 per cent. of the makers of cars will be electrically lighted in 1914.

This is not said in detriment of gas lighting or the use of oil lamps; it simply shows what the popular trend was; people wanted the greater conveniences of the electric form, and were willing to pay the extra first and extra running costs. Perhaps the movement toward things electrical on the motor car would not have gone so far, if it had been confined to lighting alone, since gas for the headlights, with oil for the side and tail lamps, have many advantages which cannot be gainsayed. But the great demand for electric starters, together with the agi-

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### How to Remedy the Most Common Automobile Troubles

**311. Why has Electric Lighting made such rapid progress in the past two years?** Mainly because of the continual agitation of the subject, and a general realization of the superiority of electric lighting for home, office, and factory use. If it was admittedly the best there, it should be on cars also, people argued.

**312. Is it cheaper than other forms?** No; more expensive, both to install, which must be put into the price of the car, and in operation and upkeep.

**313. What are the six components of an electric lighting system?** (1) Battery, (2) generator, (3) cut-out, (4) lamps, (5) wiring, and (6) operating switch or butons.

**314. Are all these necessary?** The generator may be omitted, and the battery used until exhausted, then recharged at some outside source; but this is bothersome, expensive, causes long delays, may lead to trouble on the road through exhausted battery, and has other disadvantages. If the generator be not used, the cut-out may be omitted also. This simplifies the system down to its lowest terms.

**315. What are the functions of the six parts of the system?** The battery furnishes the current, and is itself renewed and kept ready for use by the charging action of the generator. This works through the cut-out, which prevents the battery from driving the generator as a motor when its speed gets very low and the output consequently is less than the battery output. The switch is to turn on and off the various lights, and generally consists of a row of buttons for the various lights and combinations of them.

tation in the automobile press and daily papers for electrical things, combined with the arguments for a combination of the lighting, starting, igniting, and other functions into one unit, brought many persons to think that they must have electric lights, when the others would have answered just as well. Similarly, many manufacturers not exactly in favor of electricity on its merits were carried into the use of it because of the so-called popular demand for it in household and other forms.

On the other hand, the electric systems added weight in generators for the production of current if the system is to be at all permanent, and in storage batteries and wiring. However, the elimination of the use of matches, and the substitution of a button to be pushed more than made up for these. It should be stated at the outset that it is possible to maintain a lighting system with a storage battery only, but this limits the lights which can be used, practically to the side or tail lamps only, and at that for a very short time. Thus, to show this by a specific example: The ordinary tail lamp of 2 candlepower takes .42 amperes; the usual two side lights of 3 candlepower take (together) 1.26 amperes, and the ordinary 21-candlepower headlights require 7.00 amperes. An ordinary sized and commonly used storage battery is the 6-80—that is, delivering 80 ampere-hours at 6 volts. With this battery connected up to the various different lamps and starting with it fully charged, and using it until fully discharged, the length of time during which such a battery will give light is as follows:

| | | |
|---|---|---|
| Tail light only ........... | .42 amperes | 190.5 hours |
| Two side lamps ........... | 1.26 " | 63.5 " |
| Side and tail lights........ | 1.68 " | 47.6 " |
| Two headlights ........... | 7.00 " | 11.4 " |
| Head and tail lamps....... | 7.42 " | 10.7 " |
| All lights ................ | 8.68 " | 9.2 " |

Perhaps even this statement will be made more clear if these be reduced to nights of use. Supposing that the ordinary night's driving averages 3½ hours, then these figures mean that the battery will allow the driver to use the lamps in the combinations given for this number of nights, and no more:

| | |
|---|---|
| Tail light alone ................ | 54 nights plus 1.5 hours |
| Two side lights only............ | 18 nights plus .5 hours |
| Side and tail lights.............. | 13 nights plus 2.1 hours |
| Headlights only ................ | 3 nights plus .9 hours |
| Head and tail lamps............. | 3 nights plus .2 hours |
| All lights ..................... | 2 nights plus 2.2 hours |

The results are not, of course, the same as those obtained with the largest possible storage battery; in fact, the 6-100 and the 6-120 sizes would give results just 25 and 50 per cent. higher respectively. But the cost of these is much greater, while their weight is much more and the increased size calls for a larger

The wiring conducts the current from the battery to the lamps through the switch. There is also wiring, of course from generator to cut-out to battery.

**316. Should the generator fail to work, or if its shaft broke, or a wire from it to the cut-out parted, what would happen?** Nothing of much consequence, as the battery doubtless would be fully charged at the time. It would continue to supply currents to lights and for starting so long as the amount of current which it contained lasted. Then the driver would find out the need of a charging means. If the system were equipped with electrical indicating instruments, this condition of the battery would be shown before it became serious or before it was too late to remedy it.

**317. If a terminal or wire between battery and cut-out parted, what would happen?** Nothing; the situation would be the same as in the case supposed in 316. The battery would continue to operate the system as long as its supply of "juice" lasted.

**318. Where a single wire is used to supply all the current, and another single wire all the return current, is there not considerable danger of these wearing through, fraying or being short-circuited in some other way?** If the wires are of the right kind and properly insulated, there is little danger. A single ground will not render a two-wire system entirely inoperative, although it will give serious trouble.

**319. How about a ground in the so-called one-wire system?** In that case, a ground

space in which to carry them. It is for these reasons that the ordinary storage battery user clings to the smaller sizes.

However, these tables show what service can be expected before recharging when the storage battery is used directly in the lighting system, without any means of recharging the battery in the car. They show very plainly that when this is the situation it is not advisable to use batteries for anything but the tail lamp or at most tail and side lights. On this basis, the usual 6-80, fully charged, will last approximately a month before recharging is necessary. On the tail lamp alone it would last two months.

It is a comparatively simple matter to arrange a low-voltage generator anywhere on the car that a rotating shaft is available. This and a suitable electric connection that will throw out the generator as soon as the battery is fully charged and throw it back in as soon as the battery has discharged down to a certain point is all that is needed for continuous operation of the electric system, even with all lights on. With an arrangement of this kind—the one in most common use now—the battery never becomes fully discharged, for the generator keeps on charging it as soon as the current is used down to a certain point.

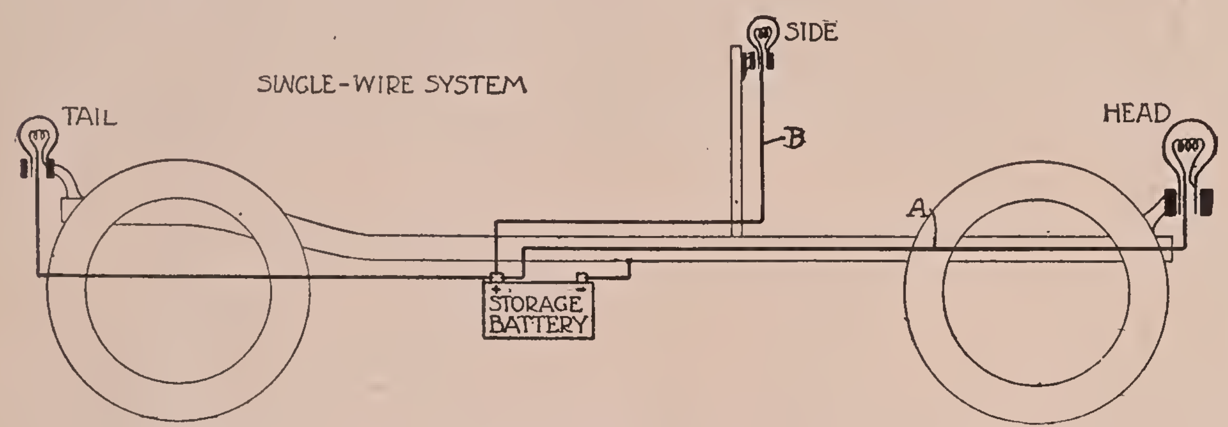


Fig. 127.—Diagram of a Motor Car Chassis, Showing the One-Wire Method of Connecting up the Lamps with the Battery, Using the Frame for a Ground.

If it were not for the fact that starting motors require a considerable amount of current, drawn all at one time also, this arrangement with the addition of a motor geared up to the crankshaft somehow would provide, in addition to the lighting, a perfect starting system. But the different demands of the starting motor and the lamp bulbs, the radical difference in the current pull, is such that when starting is considered many modifications enter.

To return to the lighting situation, there are three wiring methods in general use, called the single-wire, the two-wire and the three-wire systems. The first two utilize a 6-volt battery, and all lamps are of the 6-volt type. In the very first, the single-wire system, the frame of the car forms the return path for the current—that is, at each lamp and at the battery the frame is used as a "ground." This is shown graphically in Fig. 127. In this system, the wiring is reduced to a minimum; in fact, the whole arrangement is as simple as is possible.

The lamp bulbs have one side of the filament grounded to the base of the lamp, and the other electrode is in the center of the plug. While all this talk of wiring, electrodes, etc., may be confusing to the reader who knows nothing of electricity, it may be explained in a very few words by saying that a complete metallic circuit is necessary or current will not flow. In this case, as Fig. 127 shows, the frame of the car is used for the ground or return circuit for the current, the supply portion of the circuit in each case being formed by the single

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other than the usual ones at each of the lamps will make the system inoperative.

**320. In the so-called three-wire form, suppose a lamp burns out or the filament becomes broken?** Except that this particular lamp does not give light, there is no other effect. As soon as the lamp is provided with a good, new bulb, light will be forthcoming again.

**321. Is this the case in all systems?** No; if the lamps are wired up in series, as, for instance, 2 3-volt lamps as the tail lamp and speedometer light used together in series with a 6-volt battery, when one lamp burns out or goes out for any reason, it pulls the other out with it, and makes the series inoperative. In the case of a pair of 6-volt side lamps used with a 12-volt current, the same thing happens, when one light fails the other goes out with it.

**322. How can 12-volt batteries be used for both lighting and starting without this troublesome series wiring?** The battery can be used as if it were two, each half being wired up to a part of the lamps, ust as if it were a 6-volt unit. Then, for starting purposes, the whole battery is used so as to provide the 12-volt current.

**323. Is there any defect in this plan—that is, anything that would happen to one part which would make the others inoperative?** No, not as yet, and it has the big advantage of allowing the use of batteries of high voltage for starting while handling

wires from the battery to the light bulb, *A* to the headlights, *B* to the side lights, and *C* to the tail lamp.

In actual practice, of course, a switch would be introduced, if for no other reason, for the purpose of turning the lights on and off; as drawn in the figure, they would burn continuously until the battery was exhausted. The modern type of switch is so made that any combination of these lights may be had, as for instance tail lamp only, tail and side lights, tail and headlights, all lights.

**THE TWO-WIRE SYSTEM** is shown graphically in Fig. 128, this being more of a diagram than an exact wiring layout. The battery is located as before, but two wires run from it to each of the lights, one to carry the current, the other to act as a ground or return, so to speak, taking the place of the frame in the first case. In addition, this method presupposes a 6-volt battery, as did the first, batteries of other higher voltages being such as to necessitate a different method of wiring, moreover, it requires (as does the first) the use of 6-volt lamps throughout.

Briefly, although this seems to show the use of more wire, necessitating more work, more cost, and more weight than in the first case, this is the standard form, this situation having been brought about by the attitude of bulb and connection manufacturers toward the types of these needed in the single-wire system.

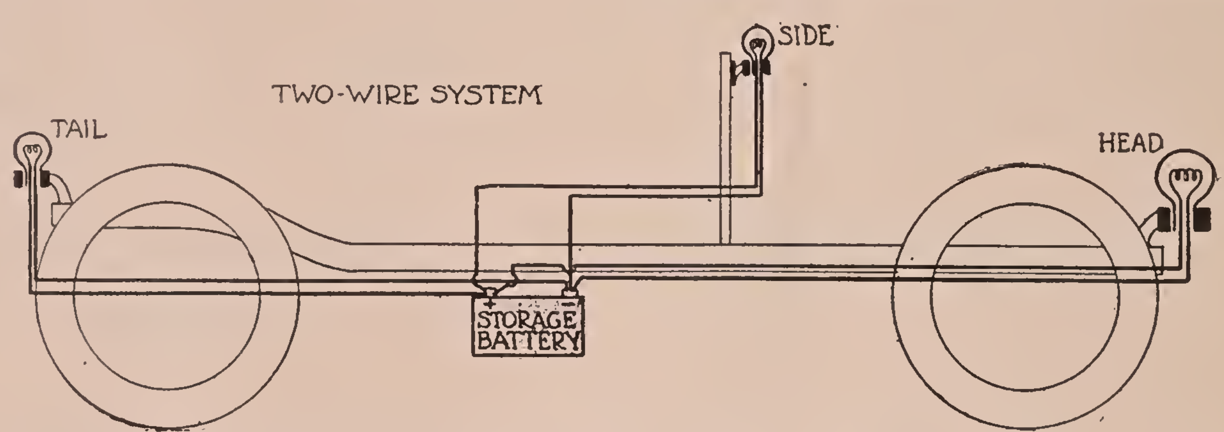


Fig. 128.—Wiring Diagram of a Two-Wire System, Showing the Additional Wire in Each Case, Which Leads Back to the Battery.

As has been pointed out previously, the battery used alone does not last very long, and consequently this method is not in favor except for use with the tail lamp only. When a generator is used, however, this makes very little change in the wiring, as will be noted in Fig. 129. This represents the same case as Fig. 128, except that it is shown in plain view instead of from the side, so as to depict all five lamps, while the switch, battery and generator connections are shown. If the various wires are followed out, it will be noted that the layout is exactly the same as before, although it looks more puzzling.

As the amateur owner should be able to trace out the various circuits in case of trouble, this will be followed through. The positive wire of the battery, marked +, leads directly to the switch, where the distribution to the three circuits is made. In following these out, it will be noted that it leaves the headlight section of the switch and flows to the wire *A*, which supplies both. Thence the return leads back to $B^1$ the one wire taking care of the return from both lamps. This arrangement gives a multiple connection—that is, the current does not have

lighting on a 6-volt basis in the usual manner. It is capable of further subdivision, and divided and 30-volt batteries may be used for the starting motor, and divided up into parts each of which would give 6 volts by the lighting wiring.

**324. If a press on the starting button, or a pull of the starting lever, as the case may be, gives no action, what is the trouble?** Probably a disconnected wire which has rendered the system inoperative.

**325. If in the case cited above no wire was found to be disconnected or worn badly, so as to cause a short-circuit, what was the trouble?** Probably a broken shaft on the generator or other mechanical trouble through the medium of which the battery did not get charged.

**326. In this same case, all of the shafts were found to be in good condition?** Then the cut-out was out of order, and allowed the battery to use up all of its current in driving the generator when the latter had been thrown out of engagement. Either that, or it had an internal ground by means of which the battery discharged.

**327. How can one tell when a storage battery is fully charged?** By means of electrical instruments. The voltmeter should show a reading of almost 2½ volts a cell. The hydrometer, which is an instrument very much like a large thermometer, and is dipped into the liquid, should show a reading of 1,280 to 1,300.

**328. If the voltage does not reach the figure named or anywhere near it?** Providing

to pass through one lamp to reach the other, but goes to the two simultaneously.

Next comes the side-light circuit, the wires being marked *D* and *D*[1]. It will be seen that the return from the former—that is, from the left-hand lamp—joins the common return at *B*[1], while that from the latter comes into it at *B*[2]. The tail-lamp circuit is equally simple, this joining into the common return at *C*. If the horn were to be connected onto this circuit, it will be connected across ahead of the switch—that is, to the plus wire, as at *E*, and to the common return, as at *F*, the dotted line indicating the horn circuit. As this carries its own switch, no additional switch is necessary. If a dash lamp is used in this system, the tail lamp may be changed to a 3-volt form, and then by using a 3-volt dash bulb, the two can be connected in series in the 6-volt system. In that case, the dash lamp, which is visible to the driver, gives warning when the tail lamp goes out, but this works the other way around also, for when one goes it takes the other with it, and the failure of the tail lamp leaves the driver without a rear signal and also without any light on the dashboard.

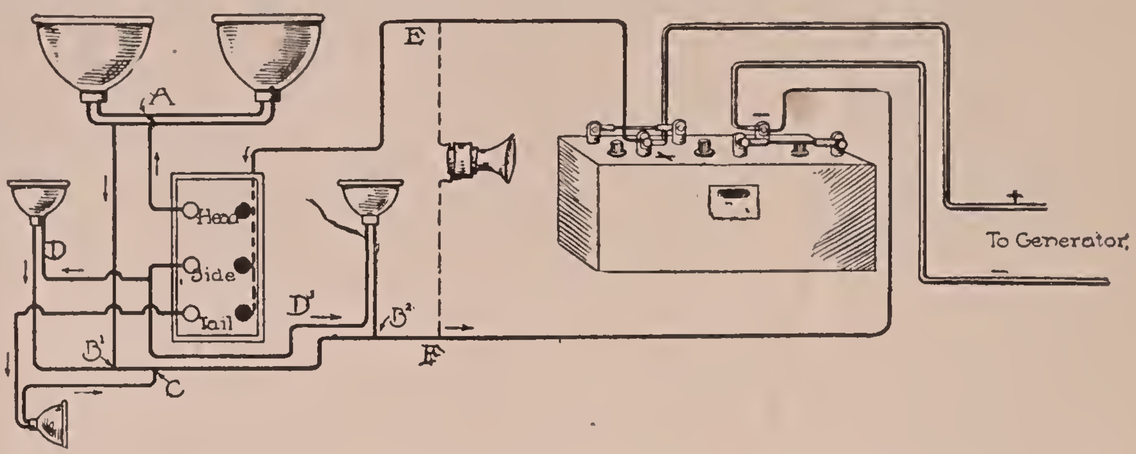


Fig. 129.—Another Two-Wire Diagram, This One Being Made as the Chassis Would Appear from Above, Thus Showing a Pair of Headlights and Side Lamps.

Parallel wiring is used usually throughout, when 12 or 16-volt batteries are utilized. With these, there are three options: Connecting all lamps in parallel and using 6 volts (the preferred method); putting 6-volt lamps in series across the line, or using 12-volt lamps. The first named calls for the three-wire method of connecting up, this being so called from the fact that there are three wires from the battery to the lamps, the former in effect being divided into two 6-volt units and so wired. By using it in this way, 6-volt lamps may be used in connection with a 12-volt starting system, the motor for the latter being connected so as to take the maximum voltage of the battery.

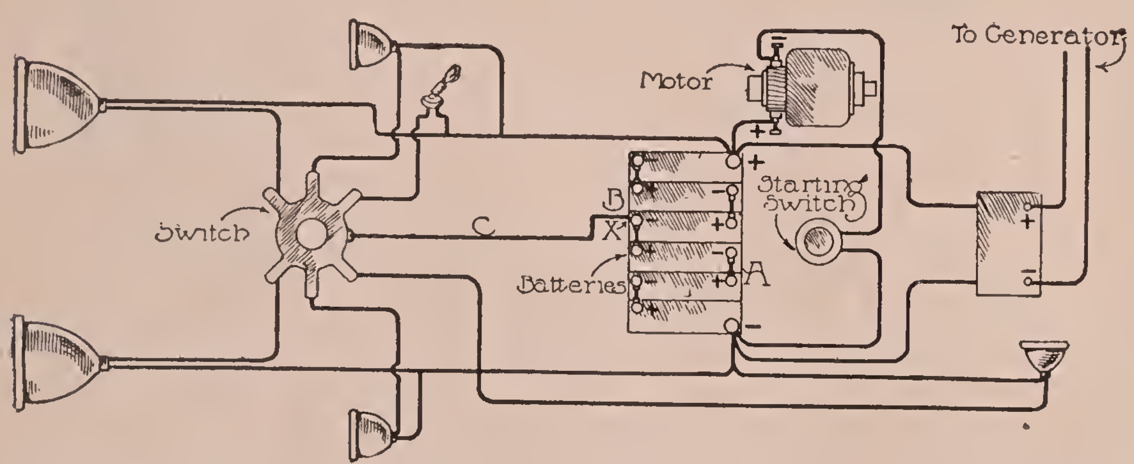


Fig. 130.—Wiring Diagram of the Three-Wire Method, Indicating the Use of a 12-Volt Storage Battery with 60-Volt Lamps. The Starting Motor Is a 12-Volt Unit, and Takes the Entire Battery Current.

The difficulty with the 12-volt system, which is extremely simple as to wiring, lies in the use of 12-volt bulbs in the side and tail lights. The series connection has the serious disadvantage that the lights are in pairs and if one of a pair burns

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the cell is a new one, the voltage must reach this figure, or it is not fully charged. In the case of an old cell, this figure will come down gradually as the cell grows older and is charged and discharged a large number of times. Finally it will reach a point just before it must have new plates when the maximum reading for a fully charged condition will be but little over 2 volts.

**329. In charging the battery gets very hot, so hot that it is uncomfortable to hold the hand on it?** It is being charged at too rapid a rate. If the temperature rises above 100 degrees Fahrenheit in charging, the rate is too high.

**330. If the rapid charging is persisted in, in spite of this knowledge?** The plates will be buckled and made useless, consequently it will be necessary to have them replaced with new ones.

**331. If the lights burn dim, what is the trouble?** The battery may be low in current. This, however, is not always the case; it is possible that the connections are loose.

**332. What harm does it do to use lamp bulbs of a different voltage from the battery furnishing current?** If the bulbs are of a higher voltage, as for instance, 12 used with a 6-volt system, they will not show any light, or at best practically none. If, on the other hand, the bulbs are of a lower voltage, as, for instance, 6 used with a 12-volt battery, they will burn with unusual—that is, extra—brilliancy for a very short time, and then will burn out.

out, the other goes out with it; in parallel wiring, every lamp is independent of every other one.

To return to the usual method, the three-wire one with a divided battery, this is shown in Fig. 130. This may be explained as follows: The headlight current flows from the positive terminal to the right-hand lamp, then back to the switch, and by way of the wire *C* back to the point *X*, which is in effect the negative of the *B* section of the battery. This point also forms the positive terminal of the *A* half of the battery whence the current for the other headlight starts, passing through the switch to the left lamp then back to the negative terminal. In this method of wiring, it will be seen that the wire *C* performs an unusual function in that it carries currents in opposite directions, actually only the difference of the two current values, if there be any, passing through it. When the two are exactly equal, as when both lamps draw the same amount of current, no electricity passes through the wire *C*.

The one side lamp and the speedometer or dash lamp are served by the right-hand half of the battery *B*, while the other side lamp and the tail light draw from the left-hand half *A*. As will be pointed out later under Starters, however, the starting motor takes current from both halves, the wiring being across the final terminals. This arrangement divides the battery into two 6-volt halves, each one of which operates a part of the 6-volt lighting system, while the entire 12-volt battery comes into play, furnishing the motor with 12-volt current when starting.

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**STARTING** is a more or less dangerous performance when attempted by hand, and when the person attempting it does not understand what he is doing. If the spark be advanced ever so slightly, or if it is possible for a spark to be created in any manner, beyond a very retarded position, there is the possibility of this explosion occurring before the piston reaches the top of its stroke. In that case, it will be driven backward instead of forward, and from the construction of the starting crank, which is such as to free itself when the engine turns forward but to clutch it otherwise, the crank will be driven backward and the operator's hand and arm with it.

This is called a backfire, or back kick of the motor, and such accidents frequently occur and persons are seriously injured in this way. The possibilities in this respect have been dwelt upon to such an extent in the trade and public press that almost everyone having anything to do with cars, and knowing anything at all about them, knows that the spark must be retarded before attempting to start the engine. The advice is frequently given, although seldom accepted and used, that the crank may be held in such a way as to preserve the operator free of damage, even if the engine does kick back.

There are two ways in which this may be done: For the first and simplest, the handle of the starting crank should not be grasped with the thumb and fingers wrapped around it in opposite directions, as is the case with a baseball bat or golf club, but rather the thumb should be folded down alongside of the first finger and only the fingers wrapped around the crank. This is shown in the sketch, Fig. 131, more plainly than words explain it, the right method being shown first and the more usual but wrong way second.

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**333. If the battery leaks, and the electrolyte attacks the metal or wood of the battery box?** This is a sign that one or more of the hard rubber cells are broken. These must be replaced by the factory or its nearest supply depot.

**334. When electrolyte is spilled, as when pouring it into a battery in place, or when the hard rubber cells break, as mentioned above, what should be done?** Everything on which it falls should be wiped over several times and very thoroughly with a cloth saturated in ammonia to neutralize the acid. Use the ammonia as strong as possible, or, if it is obtainable only in a weak form, use plenty of it, and repeat the wiping several times.

**335. Lamps show up dim in very cold weather, although the car has been running a good deal and the battery should be fully charged?** This is the nature of a battery, its efficiency is reduced as the temperature drops, and at zero is but 50 per cent. Allowance should be made for this in cold weather, and the lamps used as little as possible.

**336. What are the various systems of using and generating the various currents demanded by the modern motor car?** These consist of the four different combinations for producing the three different things—current for ignition, a steady demand; current production for starting and lighting, an intermittent demand, and a motor to permit the

The reason why this simple expedient helps is because the firing back forces the crank against the thumb. Ordinarily, it is a difficult and a slow thing to do to raise this without moving the fingers, it being natural to let go with the thumb last when gripping any round object in this way. With the thumb alongside of the fingers, when a backkick occurs the backward motion of the crank simply opens the fingers and slides harmlessly through them.

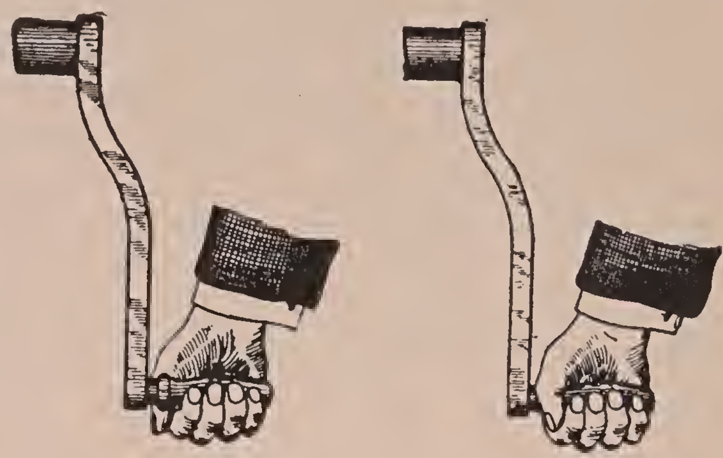

Fig. 131.—The Right and the Wrong Methods of Holding the Starting Crank so as to Be Safe from a Back Kick. When Holding It Correctly, as Shown at the Left, the Fingers Open and Release the Crank.

The second way of avoiding a painful accident in cranking is to use the left hand instead of the right. This, however, is awkward to persons who are naturally right handed, and use the right arm for almost everything. When cranking with the right hand, as shown at the left of Fig. 132, the backward movement of the crank is opposed not only by the position of the thumb, as just outlined, but also by the whole arm, its position at the time in the rotation of the crank when a backfire would occur being such that the whole backward force acts upon the forearm. Now in using the left hand, even with the thumb wound around the crank in natural manner, when the point is reached where the kick would come, the arm is held out to the left in such a position that no strain comes upon it, while the fingers, too, are in just the right position to open and let the crank go.

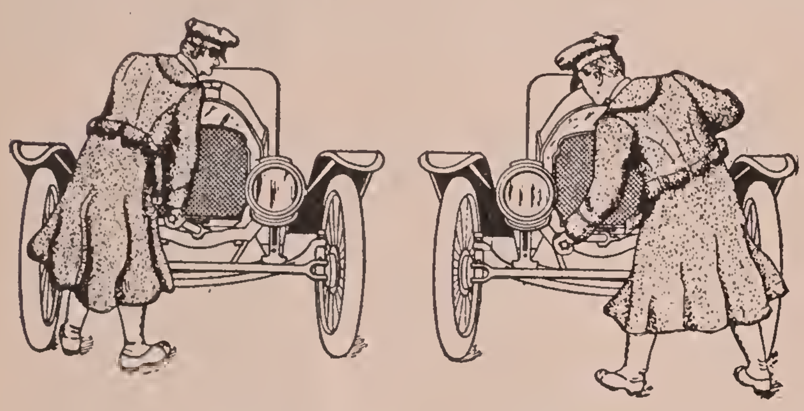

Fig. 132.—The Wrong and Right Methods of Swinging the Starting Crank Over Dead Center. When the Right Hand and Arm Are Used (as at the Left), the Back Kick of the Crank Is Directly Against the Arm.

On account of the better grip which one almost needs for cranking big motors, many have learned to crank left handed in order to be able to use such a grip with safety. While awkward at first, it is soon learned, and the writer has been assured by those who have learned it that they would not change back and use the right hand.

**STARTING DEVICES** were brought out to avoid just this; naturally the possibility of a back kick has done much to prevent women, older people, and others who would use machines a great deal from taking to them at all, unless with a hired driver. This cut off a tremendous field for the manufacturers, and, from a gasoline standpoint, made many converts to the electric vehicle. Furthermore, with the tremendous increase in the size of motors of the years 1910, 1911, and 1912, it made starting a most dangerous matter for even the skilled ones. The reason for this is apparent, the larger the motor, the more difficult it is to crank. To make this difficulty as slight as possible and insure a start on the first turn, so as to avoid addi-

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use of the starting current to turn the engine over.

**337. What are these four combinations?** Motor-generator-igniter, a single current performing all functions; motor-generator and igniter or magneto, the former serving to generate the starting and lighting current at one time, and acting as a motor for starting purposes at another; generator-igniter and starting motor, the former acting as a source of ignition—that is, as a magneto—and as a current producer as well for starting and lighting purposes. In this case, the actual form of the device is that of a generator, the ignition being made secondary. The three separate units, each with its own particular function. In this last case, the magneto does nothing but furnish ignition current, the generator does nothing but keep the starting and lighting batteries fully charged, while the motor is used only when starting the engine.

**338. Why cannot one unit be used for all three functions?** Generally speaking, the electrical complication of the one-unit three-duties system is a greater disadvantage than the mechanical necessities of the two- or three-unit systems. The weight added to the car is very slight, not in excess of 40 pounds more for a three-unit system than for a one-unit form.

tional turning, the driver would advance the spark a trifle. Doing this successfully a few times, made for carelessness, and sooner or later the big motor "got" the driver.

The first starters perfected were mainly of the mechanical form, the idea being to substitute for muscular and dangerous effort a mechanical contrivance which would do the same work without any danger. This brought forth all kinds of levers and ratchet arrangements, including quite a few spring arrangements, a few of the latter being fairly successful. Each of these consisted of a spring which was connected up to the motor and wound tightly by it, being held by a ratchet arrangement and thrown out of engagement when fully wound.

When it was desired to start the engine, this ratchet was released, and the spring proceeded to unwind, turning the crankshaft over as it did so. When the motor started, the spring was wound up by it so as to be ready for the next time. In actual practice, these devices simply proved the well-known fact that the spring is one of the least efficient producers of movement known. In building these, it became necessary to make the springs larger and larger until the starters became almost as large as the motor itself. Moreover, with the great increase in the size of the spring and the amount of it to be wound, much more power was taken from the engine in rewinding it.

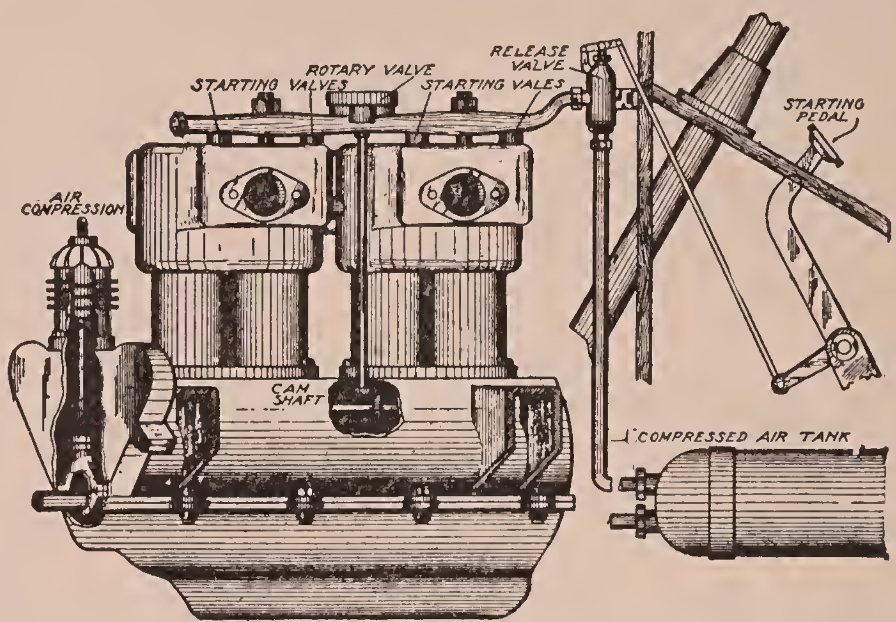


Fig. 133.—An English Air-Starting Arrangement, Indicating All the Necessary Parts and the Method of Connecting Them.

The next development was along the lines of fluid starting, with compressed air, the compression pressure of the exhaust, or compressed gas taken from the working cycle of the engine, stored in a tank, from which it was released to the cylinders through the medium of a distribution valve, when a button was pressed or a lever moved.

The use of the exhaust was not successful, the idea being to utilize something previously considered as a waste. The trouble lay in the dead, inert gases which were introduced into the cylinders, so that these could not fill with fresh gas vapor which could be ignited and thus drive the motor. The next step was a natural one, substituting good combustible gas under pressure, and obtained from the first part of the working cycle of the cylinders, for the exhaust. Theoretically, this should have been a great success, but it was not, the gas condensing to a large extent, thus reducing the pressure in the tank, while it did not prove as combustible after standing for many hours as when collected.

The air starter made considerable progress in the early days of starting devices. Here the idea was to employ a separate air compressor to collect compressed air in a tank. With this the pressure could be as high as the construc-

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**339. Isn't this system now in use?** Yes; one form of it is not only in use, but on the several makes which will be turned out during the year 1914 will exceed any other two single systems in point of numbers.

**340. What is an important element of every electric starting system?** The overrunning clutch, at the point where the electric motor drives the engine.

**341. What is its function?** It throws the electric motor out of mesh as soon as the engine speed begins to pick up.

**342. What is the need of that?** The usual reduction gearing used from the electric motor to the engine is about 30 or 40 to 1, this varying down as low as 20 to 1, and up as high as 45. Then the electric motor will revolve about 2,100 r.p.m. in order to make the engine turn 70 r.p.m. If the two were left in mesh until the gasoline engine attained a speed of, say, 500 r.p.m., which is not very high and may be expected as a usual thing at starting, the electric motor would be driven by it at the rate of 15,000 r.p.m. or higher. This would ruin it, and the overrunning clutch is put in for the purpose of preventing this.

tion of the tank would allow, this high pressure allowing for and taking care of any condensation or leakage. To start, a button or lever connected the tank of air with a distribution valve, leading to the cylinder which was ready to fire next. The pressure turned the engine over a number of turns, while the rich gas drawn in was diluted by the air in the cylinders to a point where firing was easy and natural.

One of these systems is shown complete in Fig. 133, which does not, however, make it plain that considerable extra mechanism was necessary for connecting and disconnecting the compressor with a driving shaft, as well as for maintaining the pressure automatically to a high point. Moreover, the distributing valve and its drive and connections with the cylinders and the starting lever or pedal were complicated, and added many parts and much weight.

So much was this the case that one very successful development along this line dispensed with connecting and disconnecting the air compressor, and allowed it to run all the time. The air suction valve was separated from the tank through the medium of a diaphragm, the movements of which would allow the valve to remain open, no air being drawn in in this case. When the tank pressure dropped for any reason, the diaphragm would allow the valve to close and the air would be compressed and forced to the tank.

**ELECTRIC METHODS** were tried next, the idea being that with nearly perfect compression in the cylinders all that was needed for a start was a spark. The simplest method was a short-circuiting button connected to the magneto, by pressing which a spark was obtained in the cylinder which was next in the firing order. Unfortunately, there was no way of insuring that this cylinder would have a compressed charge of combustible gas, so if a start did not result on pressing the button, it was necessary to crank in the usual manner.

A second plan, which was fairly successful, was that of rotating the magneto armature at a fairly rapid rate until the motor got a spark or enough successive sparks to start it, when the armature was dropped back into its normal place in the cycle. As shown in Fig. 134, which depicts the plan view of such an arrangement, an extra gear was connected to the armature shaft, this meshing with a long rack. The latter was attached by suitable rods and levers to a button on the dash. At the driving connection, there was placed what is called an overrunning clutch, by means of which the armature could be rotated enough to start the motor, and then when the rack was dropped out of engagement, the usual drive through shafts and gearing would pick it up through the medium of this clutch and drive it in the ordinary manner.

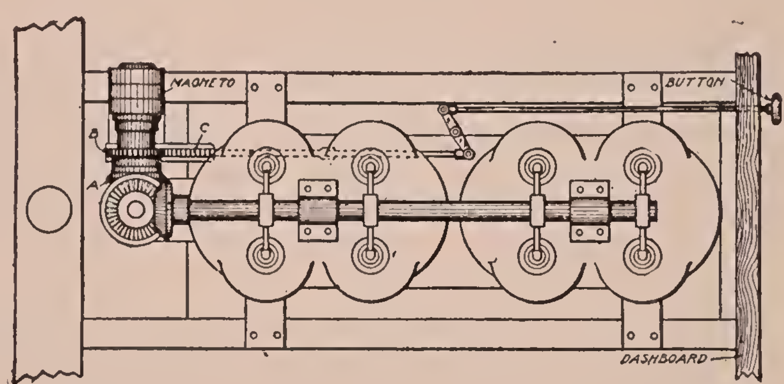

Fig. 134.—Plan View of a Starting Method Used Several Years Ago, in Which the Magneto Armature Was Revolved Rapidly by a Lever and Ratchet Arrangement.

To start with this device, the button on the dash was given a quick and vigorous pull, which shot the rack forward, engaged it with the gear on the arma-

**311A. What is the danger from starting?** That the spark will be advanced too far, so that the engine will backfire—that is, begin to run backwards.

**312A. How is this dangerous?** It carries the starting crank backwards, and with it the operator's arm. If he has his fingers gripped around the handle, as is usual, it may break his wrist or arm, or at least the fingers or some bones in his hand.

**313A. How can this be avoided?** In part by not winding the thumb around the crank. In greater part by cranking left hand, also with the thumb folded down alongside and not around the crank.

**314A. Can this be caused without the spark being advanced very far?** Yes, if the motor is hot—that is, has been running hard so as to get very hot, then stands in a hot sun, so that it does not have a chance to cool off, it is surprising on what a small advance the motor will backfire.

**315A. Is it advisable to use dry cells for lighting, and why?** Dry cells do not have sufficient current output to warrant their use for lighting. Generally speaking, a set of dry cells would not last an hour on a big pair of headlights, and a corresponding length of time on the smaller side lamps and tail lights. Moreover, this current out-

ture, rotated the latter a few very quick turns, in which the cylinders each got a few hot sparks. The rack automatically dropped out of engagement, while springs pulled it and the levers and rods back into place. Consequently, if the desired starting impulse was not forthcoming, one simply pulled the button again and again.

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**ELECTRIC STARTING,** in its modern form, does not represent the best or the cheapest arrangement, but, as pointed out previously, the one into which popular favor for things electric, coming at a time when electric lighting was being considered the best form, carried the electric starter into favor with it. The first popular cry was for a combination of starting lighting and ignition into a single unit. The people said why

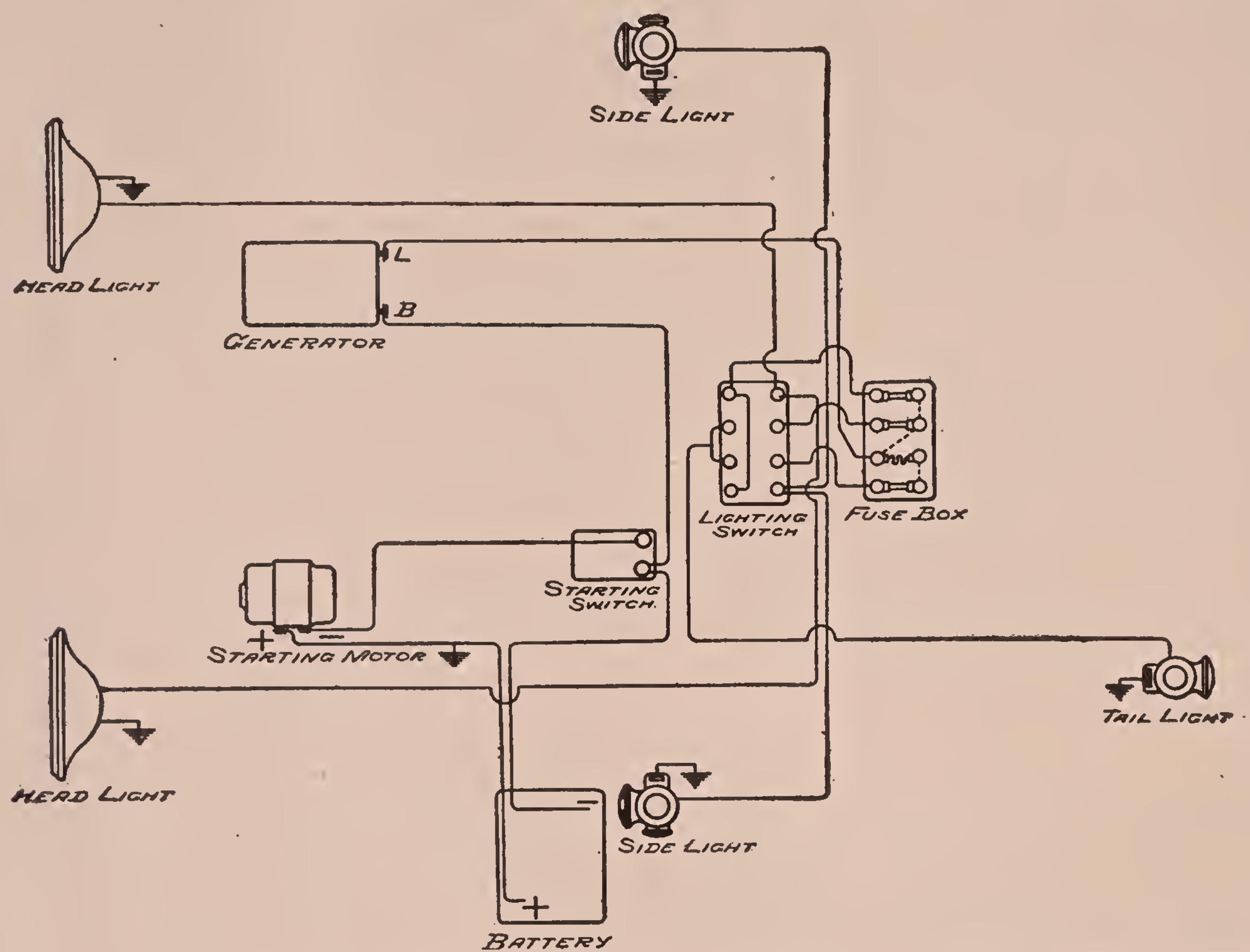


Fig. 135.—Wiring of the Units on a Three-Unit System, in Which Ignition (Not Shown), Starting, and Lighting Are Kept Separate.

have three different forms of electric current producers on the car; instead, we should have but one, doing the three different kinds of work. The answer to this, after considerable experimenting, is that the complications incident to making the one unit do the three different kinds of work is greater than is the case when all three units are used. This is shown plainly in a list of representative makers of electrical apparatus for motor cars; of these, three make single-unit systems, ten make two-unit forms, and eighteen three-unit types. That is, in a total of thirty-one, but three consider the single-unit form practical.

There are four possibilities in the units needed: First, the single unit for all three functions, as just pointed out; second, the three-unit method, with one for each different kind of work; third, the two-unit system, in which the generator

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put can not be increased in any manner, except by the use of a tremendous number of coils, wired in series-multiple as pointed out previously under ignition. In a case of this sort, the money outlay for the dry cells would equal the cost of a storage battery. When the dry cells are exhausted, they must be thrown away and new ones bought; with a storage battery, it needs but an expense of 25 to 50 cents to recharge it and make it as good as new.

**316A. What is the situation with reference to air and compressed gas starting systems?** These have some use, but their very nature makes necessary additional systems for lighting. Why use two widely different systems for lighting and starting, simply for the sake of having a gas or an air starter when the latter is not any better, and in some ways not as good as the electric starter. Other things being equal, too, a majority of people would prefer the electric light to any other form.

**317A. What units are necessary with an air starter?** First, a mechanically-driven air compressor with a means for throwing it in and out automatically (mechanically this is a delicate piece of apparatus), a tank of considerable capacity and able to withstand very high pressures for storing the compressed air, a connection with the cylinders, one to each and every cylinder and connected up to the crankshaft so that the air may always be turned into that cylinder which

is used as a motor for starting purposes, and fourth, the two-unit form, in which the igniter serves as a current generator as well.

For all three purposes—ignition, lighting and starting—a storage battery may be used, but from this it should not be thought that all storage batteries are alike and may be used interchangeably. For ignition purposes, a small amount of current is drawn, and in consequence a comparatively small-capacity battery lasts a very long time. Thus a 6-40 will last for 80 hours' running if but .5 amperes is taken for the ignition, an average figure. For lighting purposes, a minimum of 5 amperes is necessary, and the battery should be large enough to supply this amount continuously for at least 10 hours. Under these circumstances, a 6-80 battery will give 16 hours' service. Considering a starting outfit, the same 5 amperes or more is needed, and there should be a sufficient battery capacity to run at this rate for a long time, longer, even, than with lighting. For this reason, it is usual to use a 6-100, which at 5 amperes will last for 20 hours' continuous service.

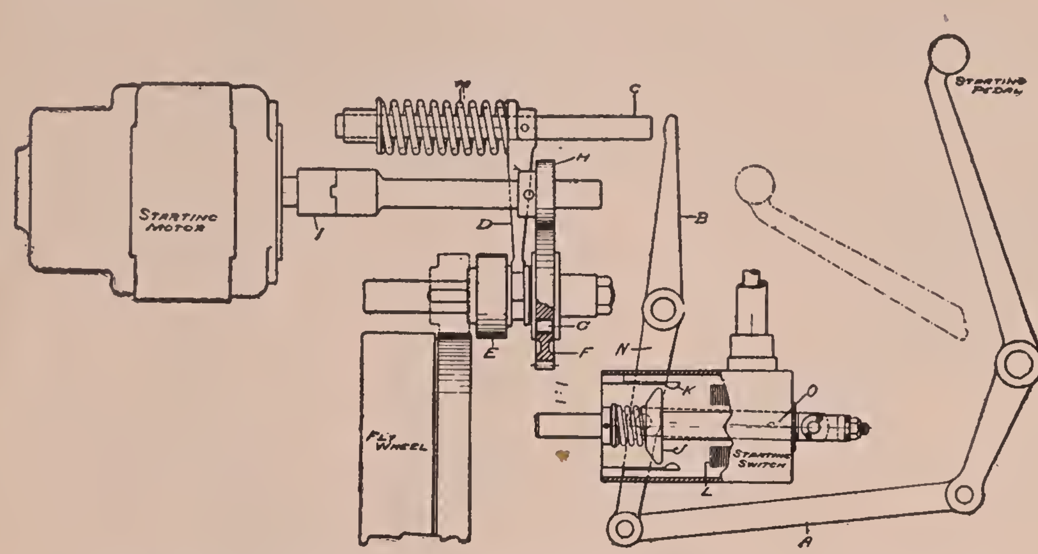


Fig. 136.—A Detail of the Starting Motor and Switch, Also the Operating Pedal of the System Outlined in Fig. 135.

Now rapid discharging ability is brought about by large surface area of the battery plates, and since the size cannot be increased materially, the plates are made much thinner. Long life under slow drain of current, on the other hand, is effected by making the plates very heavy or thick. From this it will be seen that batteries fall into one or two groups—with thick plates for long life at slow discharge rates, as for ignition, or with many thin plates for a high discharge rate, as for starting and lighting. From this, the conclusion is that ignition batteries will not serve for either lighting or starting, nor will lighting or starting batteries do for ignition; but, on the other hand, starting and lighting batteries may be used interchangeably, except as pointed out previously, the starting unit usually has a greater capacity by about 25 per cent.

Since current is needed for lighting when the gasoline engine is not running, obviously the lighting system requires a source of current aside from the rotating generator. Similarly, the starting motor must have a source of current when the motor is stationary, and one, too, which will furnish a large amount for a considerable length of time, if necessary. This means a storage battery, and, since the energy is used up so fast by these two systems, it means that a rotating generator must be included in the system to recharge the battery losses while the motor was standing idle.

This is what the generator does; in reality, the battery furnishes the current as used by the lamps and starting motor. In the various systems, there are many

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is nearest ready for it, and next into the cylinder next in order and so on. Then there must be a connection for the driver to operate throwing it into use, and most important of all, a valve on the tank which will not allow the air pressure to leak away. Some of these things are hard to do in a mechanical way, whereas with electricity they would be easy and simple.

**318A. How about the all-mechanical starters?** These represent a makeshift, a means of turning the crankshaft over without the hand being applied to the actual crank. As such they have served their purpose, and except for use on the smallest cars, have passed out.

**319A. When the electric system of lighting is used, what does it mean to add a speedometer light, any other dash lamp, a trouble lamp, an extra rear light as for the number, a light for the step, etc.?** In a battery system alone—that is, one in which the battery must be removed from the car for recharging, it will be used up more quickly that is all. In the car which carries its own charging generator, which keeps the battery fully charged at all times, it does not make any difference how many lamps or lights are added. In both cases, the wiring and switches will have to be bought and wired up properly.

**320A. Which form of electric starting has made the greatest progress to date?** In number of cars turned out, the single unit, because of its adoption by several of those makers turning out great quantities

differences in winding of armatures, of current generated, of wiring, of small accessories used, in the form of lever or button utilized to throw the system into operation, etc. In the main, however, what the user is interested in is what the system actually does, and in part only, how this is done. With this idea in view, one representative system from each of the four groups will be selected and described. This does not mean that the one described is the best or the most praiseworthy, but simply that it is representative of the group. It will be remembered that the four were given as: The three-unit form, in which a separate member is used for ignition, starting and lighting; the two-unit form, in which the generator is used as a motor for starting, so that correctly it should be termed a motor-generator; the two-unit form, in which the generator unit provides ignition current as well; and lastly, the single unit, which provides for all three functions—ignition, lighting, and starting.

In the wiring diagram shown in Fig. 135, there is presented a three-unit system, although this might not be recognized at first glance, because of the fact that

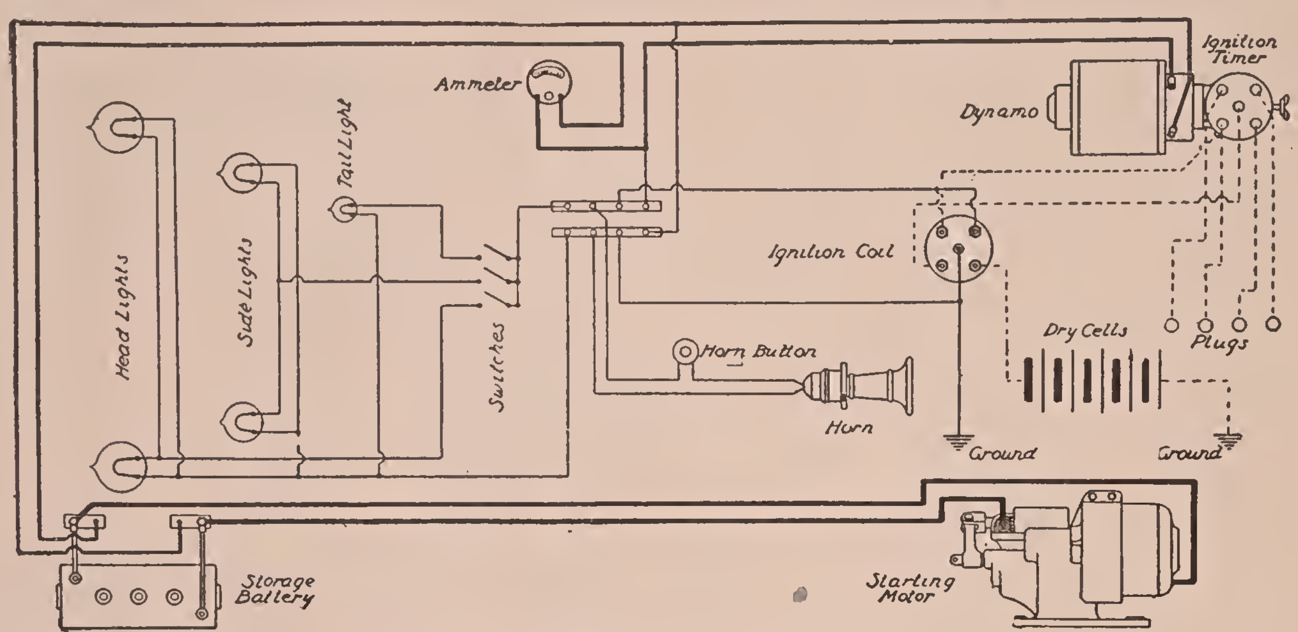


Fig. 137.—Diagram of the Two-Unit System, in Which the Current Generator Carries a Timer and Furnishes the Ignition Current.

the ignition system is not shown at all. That is, by magneto, this and the wiring being omitted for the sake of clearness. In the diagram shown of the lighting and starting arrangement, it will be noted that the starting motor is separate from the current generator, and is connected across the storage battery, while the generator connections to the lighting circuit are such that the generator runs while the motor is running, and supplies current for lights. The storage battery supplies lighting current only when the motor is not running. Thus, the three separate units—the starting motor and battery for starting primarily, the generator for lighting primarily but charging the starting battery, and the magneto for ignition—are not shown.

This system is an interesting one, and the method of applying the starting current may be of interest. This is a combination of a mechanical and an electrical action. As seen in Fig. 136, the pedals at the right stand almost vertical normally. To start, this is depressed to the dotted position shown. This draws

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of cars each year, one of them, for instance, using it for two years before it came into general favor. In number of different makes of cars, the two-unit form probably leads, with the three unit a close second.

**321A. What further advantage of a starting motor is peculiar to several of the starting systems now on the market?** The connection with the motor is constant, so that whenever the engine speed drops below a certain fixed number of revolutions, the starting motor automatically drives it. This makes it impossible to stall the engine no matter how much it is slowed down, and a load then thrown on.

**322A. Where does this quality show to the best advantage?** In city traffic, where the engine often is throttled down to a very slow speed. Then, when it is desired to go ahead quickly, the load thrown on the engine suddenly, is a little more than it can handle, and it is stalled. With this method of connecting the starting motor to it, this becomes impossible, so that when the load is thrown on in such a case, not only is the engine furnishing some power but the contents of the battery is available through the electric motor, in addition. Considering such a condition as stalling the engine on a railroad track, this connection of starting motor and engine is actually a life saver.

**323A. What must every electric system using a motor to turn the engine over, have?** Among other things, it must have a form of clutch interposed between the motor shaft and the crankshaft. This may be of the

back the lower lever, and with it the rod *A*. The latter in turn operates the lever *N*, whose upper end is marked *B*. The latter strikes the end of the movable shifter *C*, and moves this forward, carrying with it the spring *M* and the shifting fork *D*. The latter moves the gear *E* along the shaft to which it is keyed to the dotted position where it meshes with the teeth milled in the edge of the flywheel. As the starting motor through the shaft *I* drives the gear *H*, and this in turn meshes with the *F* on the same shaft with *E*, the moving of this gear places the motor in a position to drive the flywheel as soon as current is supplied to it.

This is effected by means of the starting switch, shown in partial section at the bottom. When the rod *A* moves the lever *N* to the right, as just described, another lever fastened to it and connected to the shaft *O* and shown in dotted lines moves the latter to the right in a similar manner. This draws the expanded portion of the shaft *J* into contact with the two side members of the switch *K*, thus making an electrical connection between battery and motor. As this action takes place at the same time as the making of the mechanical connection with the flywheel by means of the gear *E*, as soon as the movement of the latter is completed, current flows, the motor turns the gears, through them the flywheel and crankshaft, and the engine starts. As soon as this is completed and the engine begins to turn over properly, the foot pressure meanwhile having been removed, spring *M* will have moved the shifter *D* back, carrying with it the gear *E*, so that the starting motor will no longer be in mesh with the flywheel.

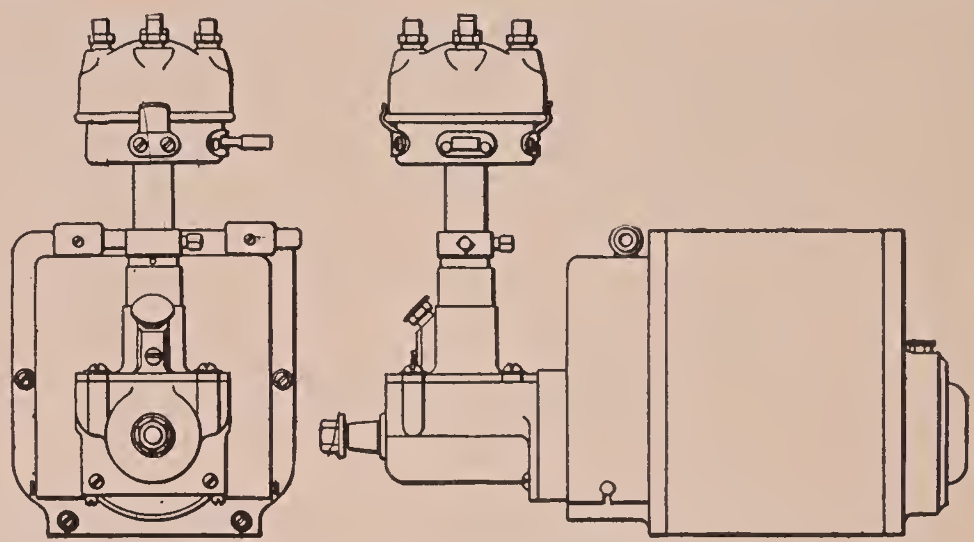

Fig. 138—The Current Generator of the System Shown in Fig. 137, Showing the Distributor Arrangement on the Front End of the Housing.

At the same time, the movement of the levers will have taken *J* out of engagement with the halves of the switch *K*, so that the current will have been shut off also. One is as important as the other, since the reduction gearing may be as high as 20 or more to 1; 20:1 being a common ratio, when the engine attains a speed of, say, 1,500 or higher, if the gears were left in mesh the engine would be driving the motor at a rate 20 times greater than this, or at 30,000 r.p.m. Even though wound for very high speeds, any such rate as this would ruin the motor at once. Throwing out the electrical connection, saves the current. With the motor disconnected mechanically, it becomes quite unnecessary to rotate the gears idly, this simply serving to waste current.

A two-unit system in which the generator serves the double purpose of a current producer for starting and lighting, and also for ignition is that shown in the wiring diagram, Fig. 137, the combination generator and igniter being seen in Fig. 138. This system includes a 6-volt motor for cranking the engine through gears, the standard reduction being 34 to 1; a dynamo or generator for charging

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roller or any other type which will work every time.

**324A. Why is this necessary?** When the electric motor drives the engine, it does so through a reduction gear, which may include a reduction as high as 35 to 1 or higher. On the other hand, if the engine were driving the electric motor, this would be a multiplying gear in the ratio of 1 to 35; that is, the electric motor shaft would be driven 35 times as fast as the crankshaft. This speed would be entirely too high for the windings to stand with safety, consequently the roller clutch is interposed to throw out automatically whenever the engine speed rises above a point where it would be driving the motor instead of the motor driving it, and driving it too fast because of the gearing ratio which speeded it up. Generally, this clutch is set to throw out at about 500 R.P.M., as even at that comparatively slow engine speed, with a ratio of gearing of 35 to 1, the electric motor would be turning at the rate of 17,500 R.P.M.

**325A. Are there many electric lighting systems in which the current generator supplies direct to the lamps, so that no batteries are used?** No. This is used only on motorcycles and the cheapest of cars. It has the great disadvantage that there is no light when the engine is not running. This means that when the car is to be left standing at the curb, the motor must run continuously, else there will be no light, this, too, no matter how long it is to stand there.

a 6-volt storage battery lighting the lamps and for other work; a 6-volt storage battery of 120 ampere-hours capacity built for heavy momentary discharges as high as 300 amperes, and an ignition timer incorporated in the generator.

The dynamo runs all the time, while the starting motor is in operation only when actually starting the engine. The generator is driven at crankshaft speed, the same as the ordinary magneto. This commences to charge the battery at 250 r.p.m., equal to 7½ m.p.h. with 34-inch wheels, and a 3.5 to 1 gear ratio. At 375 r.p.m., it gives 5 amperes; at 480 r.p.m., 8; at 575, 10; at 700, 12, and at 1,000 r. p. m., 15 amperes. This insures the battery being kept charged, even at the low speeds of city driving.

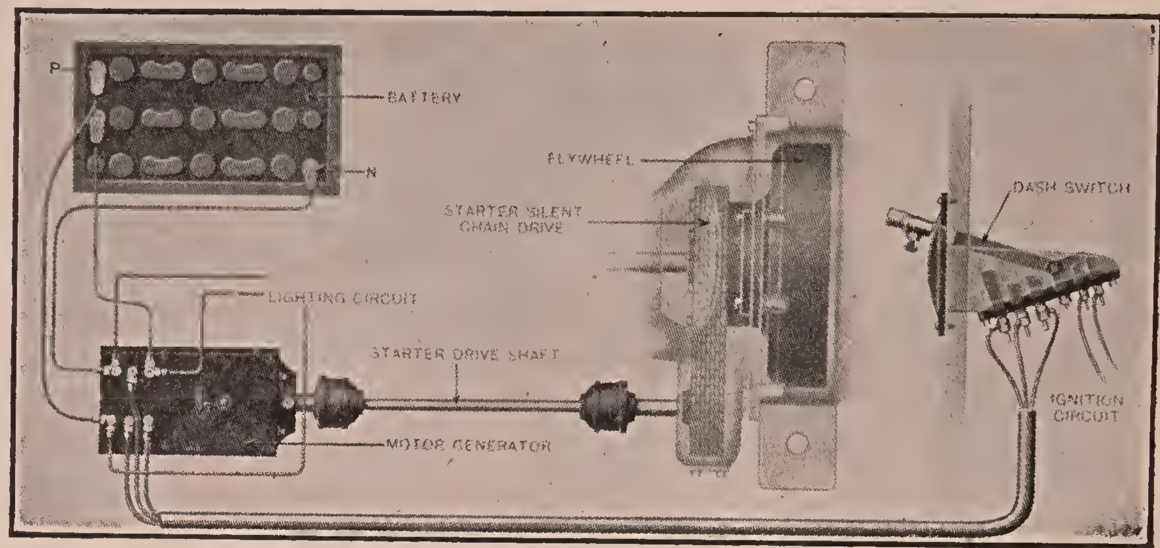


Fig. 139.—Two-Unit System, in Which the Generator Acts as a Motor Also, the Same Being Connected to the Engine at all Times. The Ignition Is Entirely Separate.

In any case of this sort in which a current generator is connected to a battery and the former is run continuously, there exists the condition that so long as the speed of the car is fairly high—say, from 10 to 12 miles an hour or higher—current will flow from the generator to the battery, which is right and proper.

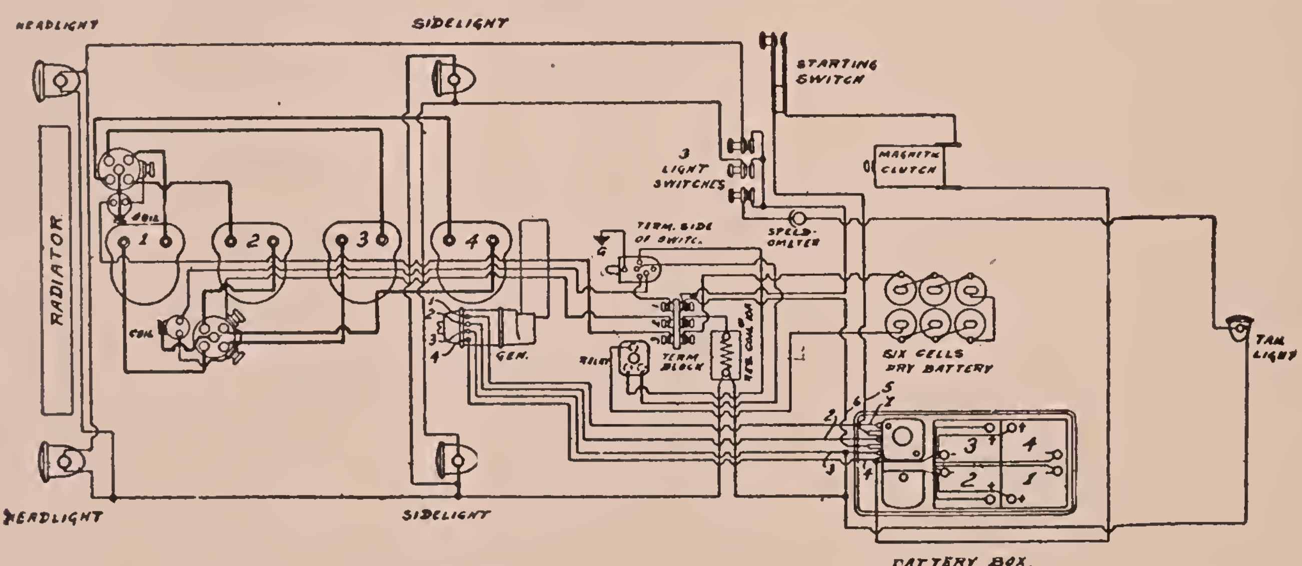


Fig. 140.—System in Which a Single Unit Performs the Triple Functions of Starting, Lighting, and Ignition. This Shows the Complete Wiring Diagram.

But as soon as the car speed falls much below this (with the apparatus just described below 7½ m.p.h.), current will flow back from the battery to the generator and be wasted. This points out the need of a device which will open the circuit automatically as soon as the current reverses. Because of this starting point, all devices of this kind are called reverse current cutouts.

These may be hand-operated, mechanical, electro-magnetic, or chemical; no matter of which kind, so long as they do the work. In the system just described, this is of the magnetic type, and is incorporated in the dynamo housing. In the light of what has just been said, and what was said previously under lighting, the ignition and lighting arrangements of this system, as laid down in Fig. 137, are plain enough.

Starting is effected as follows: The first movement of the pull rod on the motor, this being operated by rod connections to a lever or pedal at the driver's seat, closes the battery circuit to the motor through a resistance, so as to revolve the motor slowly and facilitate the meshing of the gears. Continuing the movement of the rod causes the motor to operate at full power. The gears are now

in full engagement with the flywheel, and the motor is turning over as fast as possible. Starting completed, the release of the lever allows the working parts to return automatically to their positions.

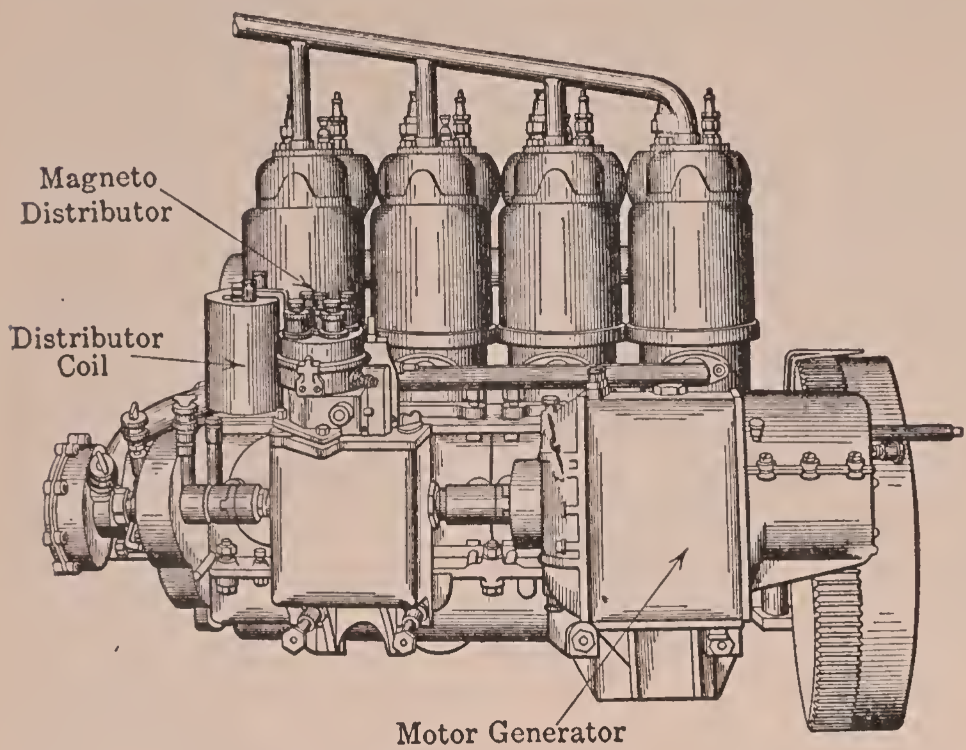


Fig. 141.—Side View of an Engine Fitted With the System Outlined in Fig. 140, and Showing Its Simplicity. The Single Unit Is Seen at the Right, Marked Motor Generator, the Coil and Distributor at the Left Being Parts of the Ignition System.

Another two-unit system, but one in which the generator is used as a motor while the magneto is separate and used for ignition, is seen in Fig. 139. In this it will be noted that the motor-generator is positively connected to the engine, so that it runs all the time. When running as a generator, it charges the battery which provides current for the lights and horn, as well as for starting.

The starting motor is put into action by means of a hand lever on the dash, depicted at the right. One movement of this turns the battery current into the motor, and since this is always connected with the crankshaft, the engine is turned over. As soon as it picks up, the switch is moved to another notch, the direction of the current is reversed, and the motor becomes a generator which proceeds to build up the storage battery. The positive connection of motor-generator with the engine has this advantage that the motor cannot be stalled, for as soon as the speed is reduced to a very slow speed at which the engine would stall ordinarily, the electric system takes up the action, and does not allow the motor to stop.

The one-unit system depicted in Figs. 140 and in place in Fig. 141 furnishes low-tension current from the motor-generator to a distributor coil, thence to the distributor proper. In this manner the ignition current is generated, boosted to high tension, and timed properly for the firing order in the cylinders. The storage battery used comprises twelve 2-volt cells arranged in four groups, each set aggregating 6 volts. An automatic controller connects these four sections in parallel, so as to provide 6 volts and 80 amperes for lighting, or in series so as to give a voltage of 24 and an amperage of 20 for starting.

To start the engine with this system, the clutch pedal of the car is pressed down and a switch button pressed. The former engages a pinion on the motor generator with other gears, which in turn mesh with the flywheel gear teeth. The latter allows current to flow from the battery through a magnetic clutch actuating the starting mechanism including the motor. As soon as the engine starts, the clutch pedal is released, the movement automatically disconnecting the starting apparatus, after which the car clutch is operated in the usual manner.

# CHAPTER IX.

# The Newest Tendencies in Construction.

**NEW CONSTRUCTIONS** year since 1907 or 1908, when they were considered to have been perfected. That is to say, nothing very radical has been brought forth; but by gradual evolution, combinations, refinements, etc., constructors have found that the people take kindly to this, that or the other thing. Among those things which may be said to have changed the most are body lines, for the original motor car body was an adaptation, pure and simple, of the carriage, hence its early name, "horseless carriage." Slowly but surely this has worked around in a cycle, until to-day it presents a separate entity and one entirely different from anything ever perfected for use behind the horse. In short, the motor car body form now presents an individuality.

The latter-day body possesses, besides difference from carriages, an amount of ease and comfort never before known to travelers. This, too, has been the result of a gradual evolution; in fact, it was as late as 1912 that 10-inch upholstery, now quite general, came into vogue. Then, the perfection of springs and spring suspensions have had much to do with the comfortable riding qualities, while the gradual elimination of noise and the noise-making parts has contributed also to the comfort of the car's use. Ease and handling and operating have brought forth many mechanical improvements, some of them very closely interwoven with body work and comfort of riding.

Thus, the matter of proper control location on the right or left side seems to have settled itself in favor of the latter, while the nature of practically everyone to be right handed has located the lever on the right-hand side, which with left control becomes the center of the car. The desire to take all hills on the high gear—that is, personal disinclination to exertion in gear changing—has brought into favor first larger motors, and later a larger number of cylinders, each of a smaller size, as exemplified best by the six-cylindered engine. On the other hand, this same very human trait has brought out the electric, pneumatic, and other methods of controlling the shifting of the gears and other parts of the car's operating members.

**MOTOR CHANGES.** In addition, there have been those different forms of motor, which have been produced in the natural strife for perfection and highest efficiency in this most important part of the car. The sleeve valve motor at first appeared about to revolutionize the industry, but the perfection of the poppet form with more silence than before, greater power from a given size dunit than previously, and other matters, served to show that this would never be eliminated. In addition, a considerable number of other sleeve and rotary valve forms were brought all of more or less merit.

With greater power available, it was natural to look for and find a better method of applying this so as to increase the efficiency of the whole car, not of a single unit alone. Thus, the worm gear was investigated and modified until found suitable for automobile work, following which the skew bevel and others were found available. The four-speed gearset has been developed, also the two-speed rear axle, offering in effect six speeds forward and two reverse with a three-speed gear box, or eight and two with a four-speed form.

Summing up, then, the latest forms of mechanical perfection of the motor car for 1914 may be placed in some one of nine different classes, namely: (a)

Left-hand control and right-hand levers; (b) streamline bodies, with the attendant changes; (c) six-cylinder motors; (d) sleeve and rotary valve engines; (e) electric and pneumatic gear, clutch and brake-operating devices; (f) worm and skew bevels and silent chains; (g) four-speed transmissions, two-speed axles, etc.; (h) cantilever and other springs, underslinging; (i) air compressors for pumping tires, and similar labor-savers.

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**LEFT-HAND CONTROL** has come about very naturally, once the automobile reached that stage of perfection where there was time to think about such things. The rule of the road in England, and fast being adopted in other European countries, is "Keep to the Left." With this form, the right-side position of the driver is such that he is nearest to approaching traffic, and thus is able to gauge the distance necessary to pass it in safety very clearly. In this country, on the other hand, we adopted the "Keep to the Right" rule, but placed the driver on the same right-hand side as did the foreigners. This stationed him where he could not gauge the passing distances for an approaching car very clearly or accurately, hence for safety's sake, he was and is obliged to give a considerably greater distance than is necessary.

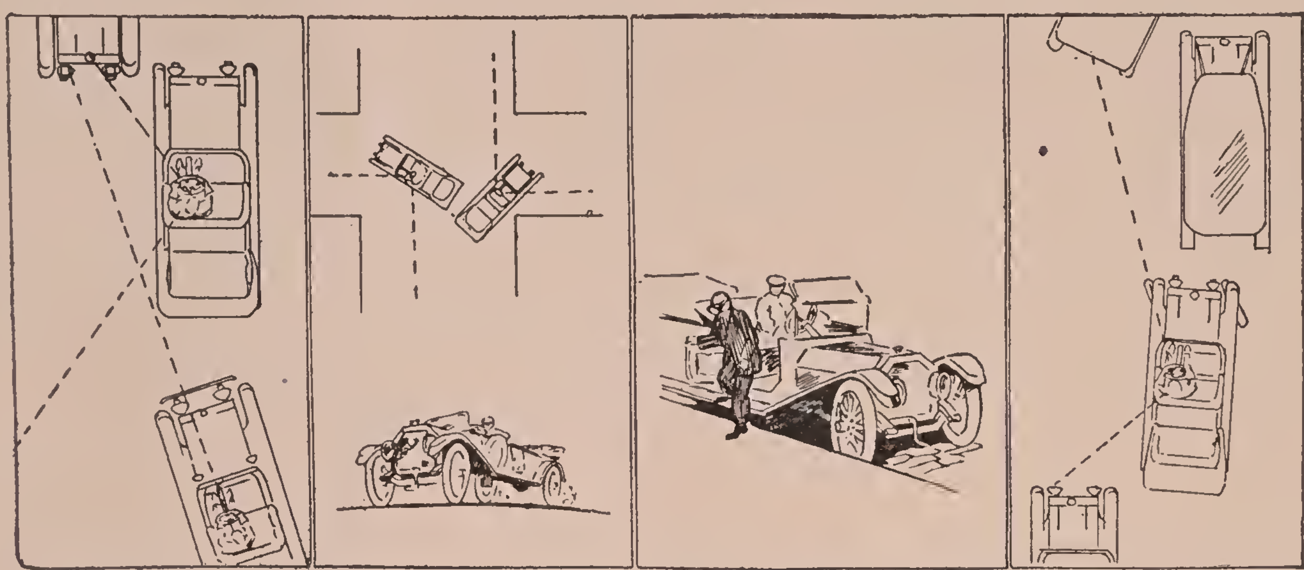

Fig. 142.—Drawing to Show the Advantages of Left Control Location in the Same Situations as Indicated in Fig. 142.

With the driver shifted over to the left side, we have the condition, under our rule of the road, which corresponds exactly to the European countries, and one which they have found very safe. There are advantages, it is true, of the right-hand location. In overtaking and passing another vehicle, it is our rule to go around it to the left, so that the driver is able to note just how he is passing it. Moreover, in a narrow road, he is able to watch the ditch side very closely. In climbing a hill with a curve just at the top, the driver is placed at a disadvantage, for

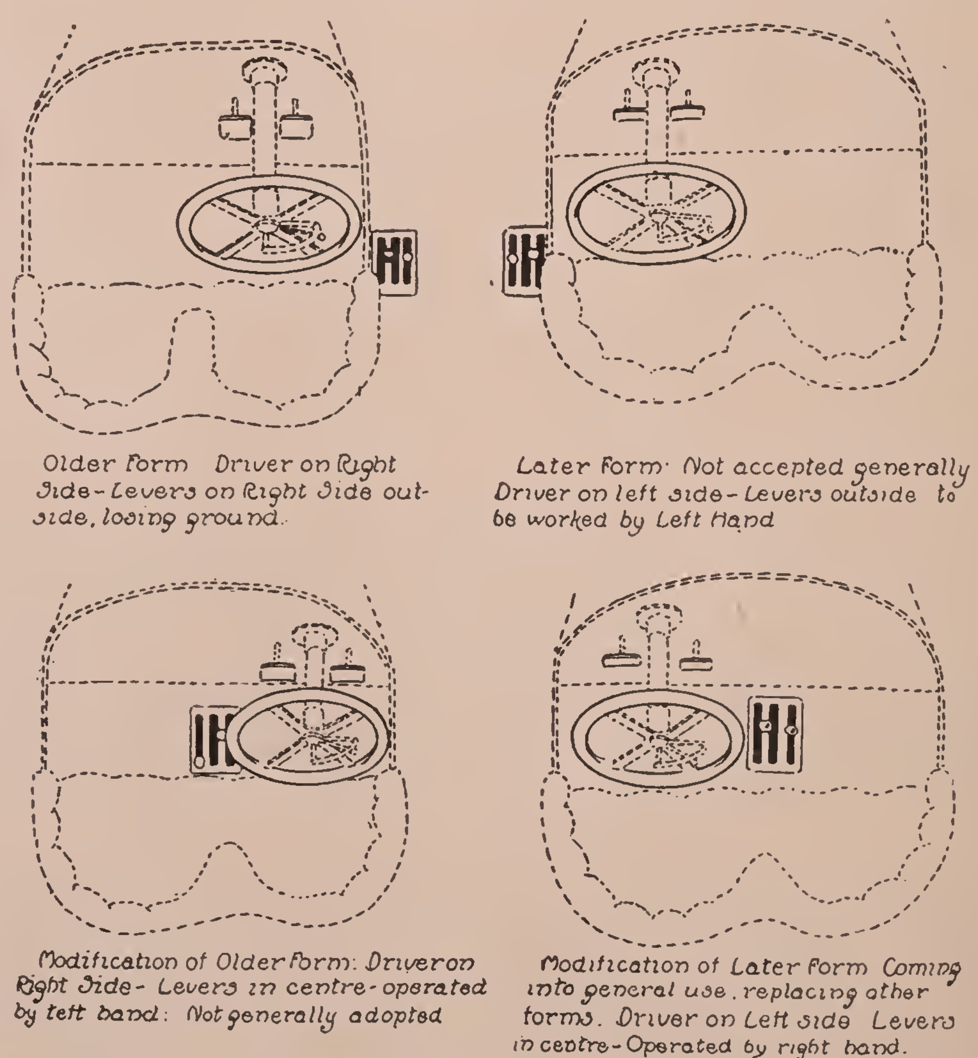


Fig. 143.—Sketches Which Show the Gradual Progression of the Location of Steering Post and Controlling Levers. This Indicates Also the Four Different Forms, All of Which Are Now in Use.

he does not see the turn as quickly. In turning a corner to the left or right, he cannot see as much of the approaching traffic on either street. In pulling up to the curb with a passenger, the latter must get out in the street and walk around, while in the actual passing of a car ahead the driver is at a disadvantage until he is alongside of the car.

In the sketch, Fig. 142, these matters are pointed out graphically, and in much the same order as they have been described, and presenting the advantages of left-hand location under exactly similar conditions. First, overtaking traffic with other approaching traffic to be considered; second, climbing a hill with a curve at the top, turning into a cross street, either to the right or left; letting front-seat passengers off or taking them on, at the curb; and going around a car or cars ahead with other cars behind. In short, this second illustration shows just the reverse of the first.

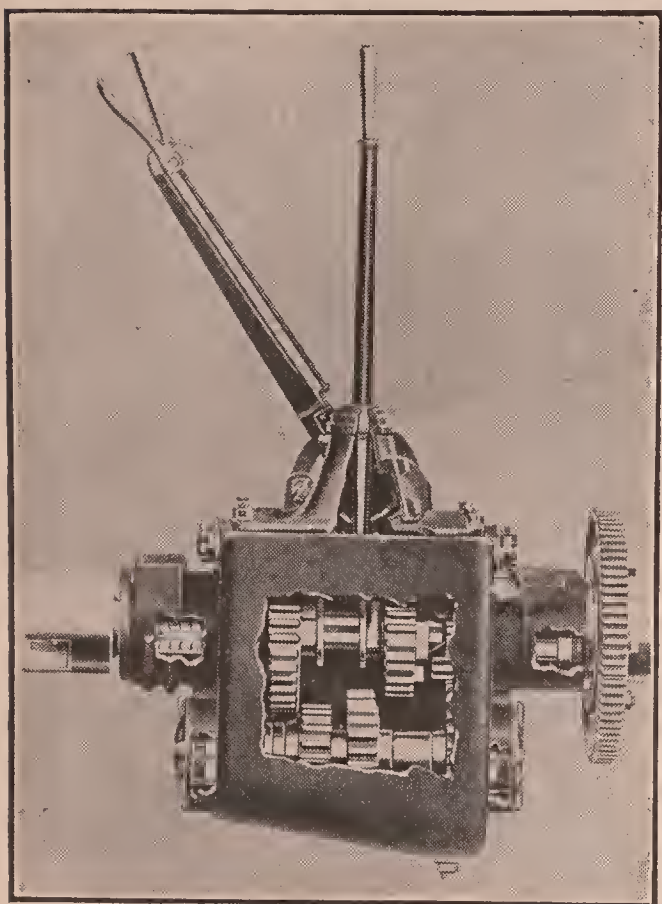

Fig. 144.—Illustration of the Levers Placed on Top of the Transmission in Unit Power Plant, Which Gives Center Control with Left-Hand Steering; Also Eliminates Many Rods, Levers and Other Parts.

Granting, then, the superiority of the left position, there is another question to be considered, namely, the location of the gear shifting and brake levers. The majority of people are right-handed, or have learned to drive in a car whose levers were operated with the right hand. If, then, the levers be placed on the left side, old drivers using the car must learn anew, while novices find it difficult to master the left-arm motions. A further consideration in this placing of the levers lies in the fact that placing them at the outside of the car, no matter which side be chosen, cuts off that side in the matter of entrance and egress. On the other hand, placing them in the center, allows the driver to enter from one side and the passenger from the other, while if the same be well placed and made short enough, either driver or passenger may get in or out on either side.

Considering this to be done, the center location then gives the front of the car one extra door, so to speak, and a greater use of the other. When the levers are centrally located with right-hand control, however, their operation is by the left hand, and consequently awkward. The whole proposition is resolved, then, into the use of left-hand location with central levers, which means operated by the right hand. This and the gradual evolution from the former right-hand location of both driver and levers, and some of the makeshifts offered the public, are shown in Fig. 143. At *A*, is indicated right-hand control, with right-hand levers, outside the body. With the first agitation for the left-side location, a number of firms simply turned the entire control over, about the center of the car as an axis, bringing the driver on the left and the levers also, as shown at *B*.

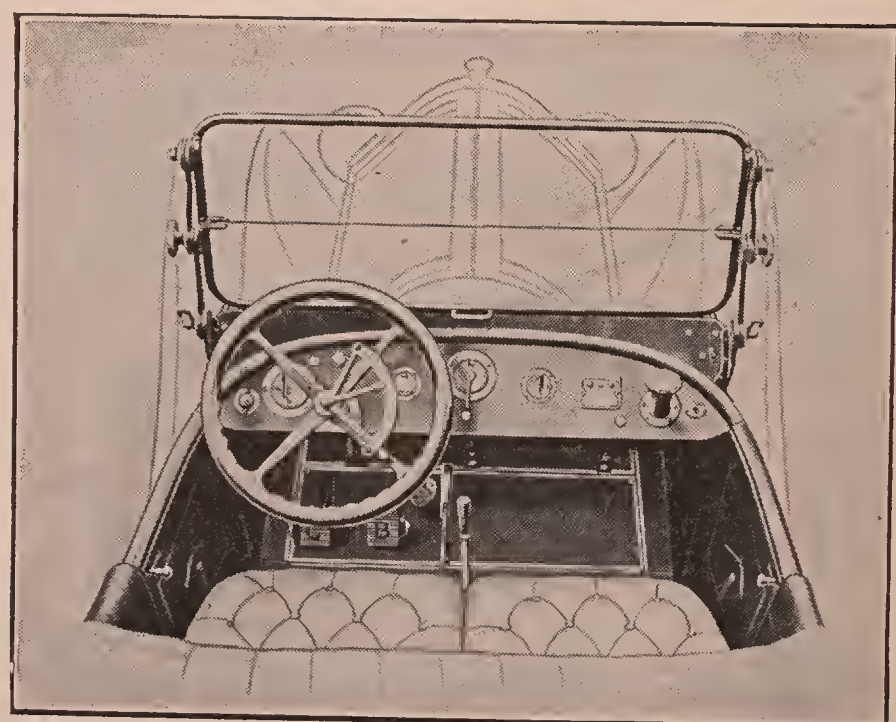

Fig. 145.—View from Behind of the Control Group of the Car Whose Transmission and Levers Are Illustrated in Fig. 145, Showing Also the Instrument Board.

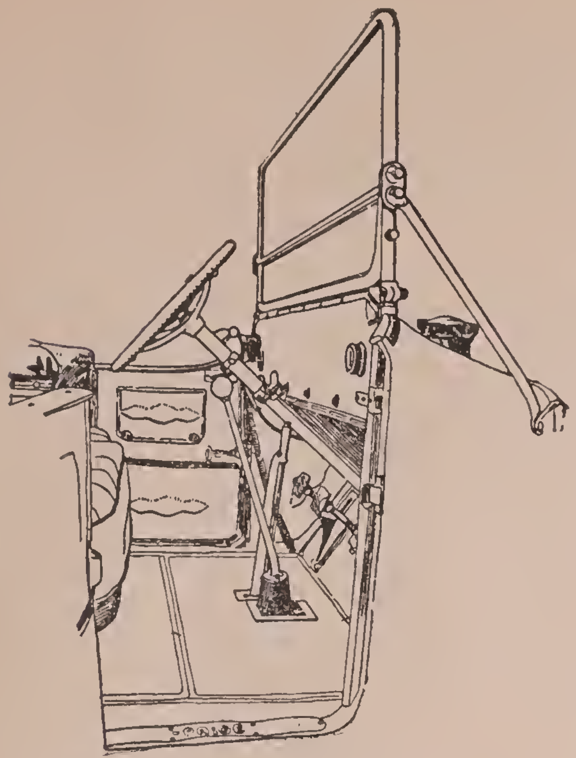

Fig. 146.—Control Group of the Paige-Detroit 36, Showing the Central Levers with Left-Hand Steering Post. Note the Cane Type of Gear-Shifting Lever.

A number of other firms, not admitting the advantages of the left position, were able to see the advantages of the centrally placed levers, and changed theirs from the right outside to the left inside, as shown at *C*. As compared with *A,* the advantage gained of the use of the right-hand door was more than offset by the necessity for using the left hand and arm, distrusted by many. Finally came the simplest and most natural form, that indicated at *D,* in which the driver is on the left side and the levers are in the center. This has all the advantages of all the other forms and none of their disadvantages.

This placing of the levers brings them right over the transmission, so a considerable number of rods, levers, shafts and bearings have been eliminated. Besides saving weight and cost, this eliminates a number of possible points for wear and noise. This is pointed out in Fig. 144, in which the levers are shown upon the transmission, while Fig. 145 shows these in the car, the same being viewed from the rear. This method of placing the levers and controlling the movement of the car, together with the need for a comparatively short lever of simple construction so as not to catch in the clothes, has brought about the use of what is termed the cane type. This is a short, light, perfectly straight lever with either an ordinary handle grip or a round ball end.

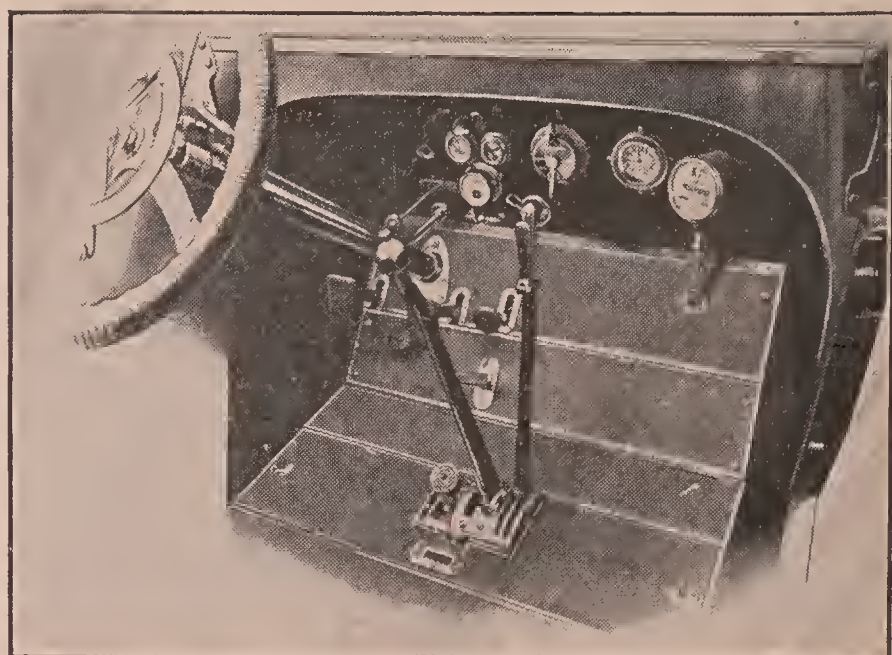

Fig. 147.—Control Group on the Lozier Light Six, Showing the Method of Gaining Space for Passage by Setting the Levers Forward. Note Also the Grouping of Control Units, Gauges and Adjustments on the Dash Handy to the Driver.

Moreover, this position of the lever has allowed of shortening the movement necessary in order to engage any one of the various gears. In fact, in some cases, as short a movement as 2 inches either way from the neutral position would engage a speed, this being measured at the top or handle of the cane. The figure just referred to, Fig. 144, shows why this is, the lever being pivoted actually at the point marked *A*. This gives the lower end of the engaging fork almost as much movement as the handle for the distances down from *A* and up from it to the top of the handle are approximately equal.

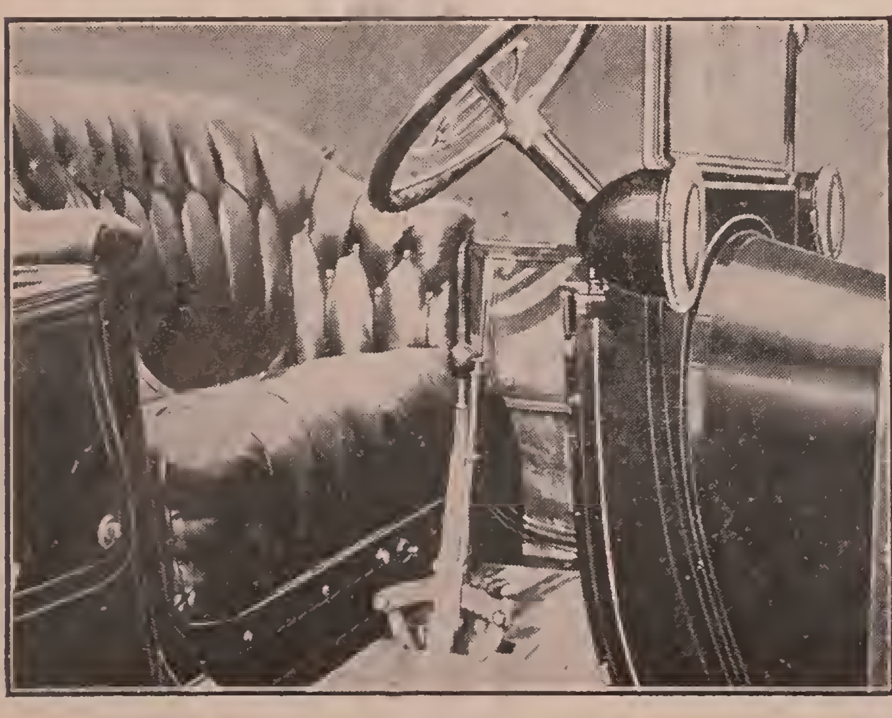

Fig. 148.—Control Group of the Chandler Six, Indicating the Use of Very Short Levers Set Fairly Close Back Against the Seats, but Giving Plenty of Passage Space. Left-hand Location, Right-hand Levers.

This one shows a plain round handle, while the forms in Figs. 146, 147 and 148 show various arrangement, using a ball handle. The first two indicate the forward

placing of the levers with a somewhat raking steering post, so that the portion of the front toward the seat is free and clear, allowing an uninterrupted passageway across. The last named, however, shows the other method of accomplishing the same thing, namely, the placing of the levers back almost against the cushions, so that the space or passageway is left in front of them. In this case, too, the levers are made much shorter than when they are placed farther forward, as in the two previous instances. This will be noted by comparing their heights above the floor with the height of the front seat cushions, the levers being considerably above this in one case and of approximately the same height in the other.

This matter of free and complete use of the front space has given designers a great deal to think about. A method by which the same effect is obtained in one car is to fasten the driver's seat by means of sliding members so that it may be moved backward or forward as desired. This has the additional advantage of permitting the same car to be adjusted to two different persons of widely different stature, and consequently of a different length of leg and arm. Another way of accomplishing the same thing is to hinge the front seats, as was done on a French body seen at the big Olympia show in London, 1913. The front seat is divided into two parts, and each of these is hinged in such a manner that it may be folded up first and then turned so as to present the least width. By this arrangement, the whole interior of the car becomes one compartment for the time being. It is conceivable that this would be very useful in such a case as a camping-out trip, or a long run into strange country when the tourists got caught away from a city and wished to sleep in the car.

**STREAMLINE BODIES,** so called because the outside of the woodwork or metal offers no obstruction or projections to the stream of air passing over it, have not been brought about by the commendable desire to reduce the wind resistance of the car, but rather to an improved appearance, to the unification of the car brought about by building the body so it appeared a one-unit instead of two or three detached ones on the same chassis, and to popular demand following the introduction of fore doors. The latter were brought out about three years ago, and were an instantaneous success. Following their use, designers of bodies began to smooth down the lines of the car so as to present a straight curve or sweep from the front to the rear. This applied to the upper line of body and doors, as well as to the bottom line and the ornamental mouldings between.

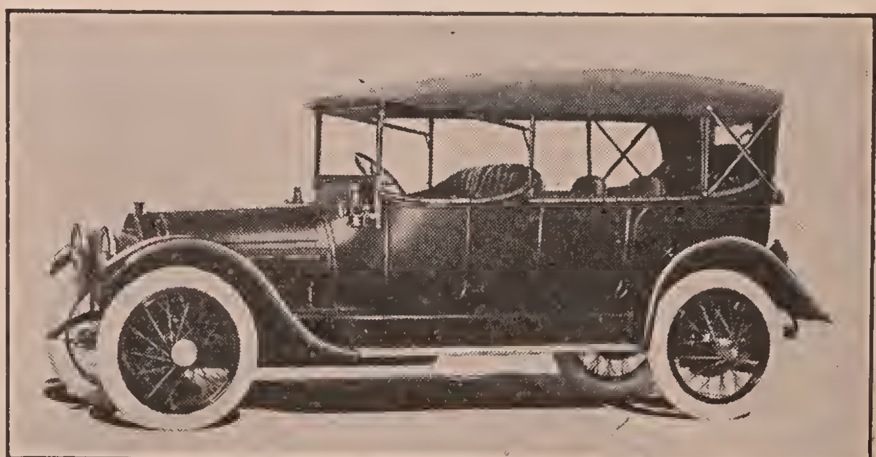

Fig. 149.—Side View of a Stevens-Duryea Six, Presenting an Excellent Example of the Streamline Body with Upward Curve at the Dash. Rounded Front and Rear Fenders, Space Between Step and Body Neatly Filled in and Other Features.

Latterly, the fenders, running-board and space between these and the body have been closed in, and the curves of all three considered in conjunction with those of the body. Following this, a slight improvement has been made by giving the outside surface of the body a slight outward bulge or curve near the middle of its height. In some cases, a very neat appearance has resulted from placing this about one-third of the height from the bottom, and then carrying the upper portion steadily outward clear to the top. This has resulted in gaining several inches in width inside of the body with the same width at the bottom, and without making the body appear any different.

A newer feature of the streamline bodies for 1914 is the curve between hood and dash line, this serving for the double purpose of making the hood seem a portion of the body, and of deflecting the air upward so as to diminish the wind resistance. In many cases, this has been accompanied by raising the rear end of

the bonnet several inches above the front, so that there was a gradual upslope all along its length, terminating in the sharp upward curve at the dash. Many of these points are seen in Fig. 149, which is presented as a typical streamline body of 1914, and in the figures following.

On examining this body closely, it will be noted that the door handles are inside, while the hinges are hidden also. Both of these points have been followed out on all the true streamline or flush-sided bodies.

A point to which attention is here called as it is not seen on this body is the elimination of the side lamps which the combination of clean body ideas and the marked improvement of electric lighting equipment has produced. The use of dimmers and two-bulb headlights has allowed of taking off the side lamps, thus further cleaning up the front end of the body.

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**SLOPING BONNETS** and dashboard radiators have added much to this streamline tendency, having at the same time the advantage of decreasing the wind resistance to a marked degree. Furthermore, this arrangement takes the most delicate part of the entire chassis, the radiator, out of the danger zone, and places it where it is very safe at all times. In addition, it may be supported better and more firmly than in the front position. Besides the well-known sloping bonnet used by Renault, Charron, and others abroad, and by Franklin, Croxton, Argo, Detroit, Borland and the majority of electric cars; Kelly, Lippard, Stewart, Willet, and a number of other commercial cars; Keeton, and other American cars, there is the wedge shape presented in Fig. 150. This differs from those just mentioned in that the top line of the bonnet is straight and does not slant toward the front, but is horizontal and parallel to the ground as far as the first break, where it slopes down sharply to the front end, where it becomes vertical. The sides, however, slope all of the way, sharply from the front edge to the break, and slightly back as far as the radiator. This form would seem to have all of the advantages of the sloping form, while preserving the appearance of the regular type for those who prefer it. This body presents another excellent example of the streamline form, although the headlights have been removed. Note the curve of fenders, the clean sides and running board, the even outward bulge of the body beginning at the radiator and continuing to just back of the rear door, where the similar inward bulge commences.

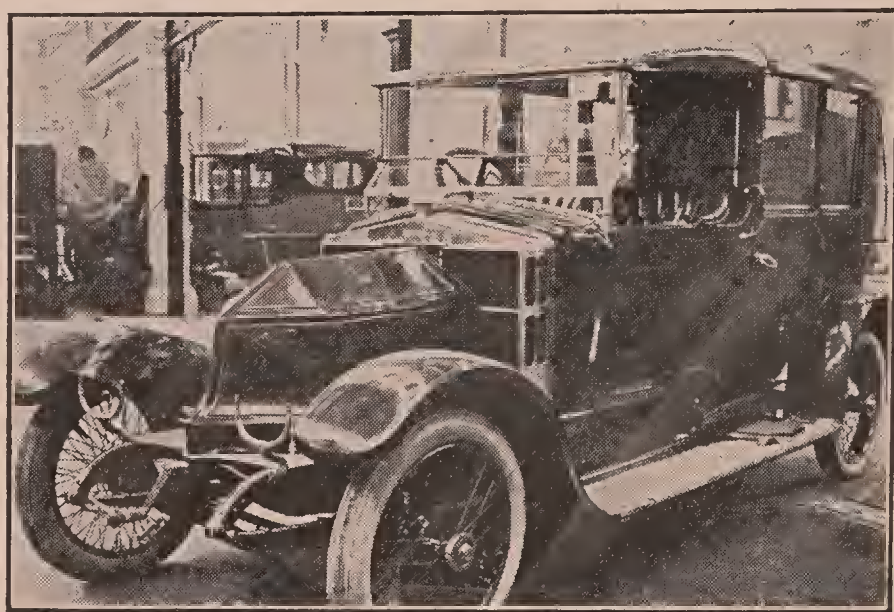

Fig. 150.—A French Type of Wedge-Shaped Bonnet and Dashboard Radiator Location Which Looks Well with the Mulliner Flush-Sided Body and Crowned Fenders.

With improvement in bonnets and radiators, in order to get a shape with less wind-resisting surface, considerable progress has been made with coolers having a wedge shape, others with a rounded front, still others with a modified wedge, and a few with the radiator in two parts, one set on one side parallel to an extreme wedge-shaped bonnet, and the other on the opposite side similarly located—that is, an extreme

Fig. 151.—Wedge-Shaped Radiators Are Increasing in Favor Rapidly, While the Use of a Single Lamp Inserted in the Water Space at the Top Is Thought to Give Better Road Light and Sim-

wedge shape, but with the sides of the radiator forming the wedge in two separate parts. This latter form has been widely used in aeroplane work, but there the matter of wind-resisting area is of vital importance, while the same cannot be said of the motor car.

The American forms of radiator other than the square-front type have not been extreme, presenting only a modest curve or very blunt edge at the front. One was brought out with a wedge and having the single searchlight set flush with the upper portion—that is, incorporated within its upper part. This, however, was soon withdrawn from the market, and this make of car is now sold without that feature. The idea of this may be gained from the foreign form shown in Fig. 151, the Delacour lamp set into the upper part of the cooler.

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**BOAT BODY FORMS** have made little or no advance in this country, as compared with France, where the last Salon, that of 1913, saw the majority of the new bodies of this form. A good idea of this may be gained from the illustration, Fig. 152, which shows a Gobron exhibited there. In this, the wedge-shaped radiator is new. Note how the boat idea is carried out at front and rear, in the projecting sidelamp, cleverly designed to look like a ventilator funnel, in the side opening for lighting the driver's compartment, made to resemble the forward deck of a boat, in the planking and copper riveting on the boards, and in other ways. In some of these boat bodies the boards were selected so as to be alternately of contrasting wood or colors. When this was done, the same idea was carried out in the fenders, which were made of a slat form, like the removable bottoms of boats, in the wooden protection for the rear gasoline tank, and in other ways.

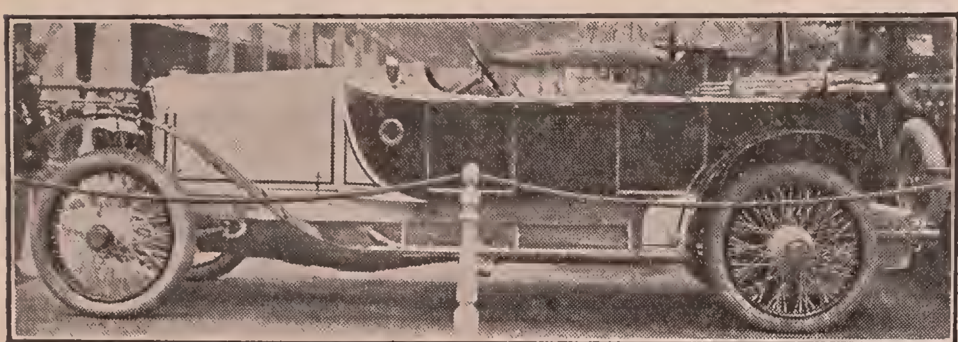

Fig. 152.—Boat-Shaped Body on a Gobron (French) Chassis, Showing How Faithfully the Boat Idea Is Carried Out in Planking, Rivetting, Lamps, Openings, Stern, Etc.

Of course, these represent the extremes, between these and the ordinary streamline forms there were many which should find favor and remain in vogue for a long time. The boat idea, with the additional idea of reducing wind resistance to a minimum compatible with a fine appearance, is an excellent one, and should result in greater speed and more power from similar sized motors, and greater mileage on a gallon of fuel, or, on the other hand, should allow of the use of smaller motors with the same sized car, thus lowering the first cost as well as the maintenance cost.

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**SUCTION** at the rear end of the automobile has been set down as one of the greatest influences in making the car a destructor of highways. It is now quite generally conceded that the manner in which this happens is as follows. Horse-drawn traffic passes over the road, and by means of the horse's shoes and the narrow iron-tired wheels, the surface of the road is cut up and the material loosened. Then a motor car comes along, and, through suction, picks up this loosened part and wafts it off to the grass, ditches, fences, etc., at the side of the road. In this way, the lighter dust is carried off first, then later the larger parts of the material comprising the road bed are cut up or ground up by the horses, and "blown" off the road by automobiles. With the idea of lessening this destructive effect, considerable work has been done toward rendering bodies of such a shape that they would not create any suction at the rear.

One of these is shown in Fig. 153, the picture taken from the rear, bringing out the shape in a marked manner. Note that the rounded bulge at the rear, extending down beneath the car frame as well as above it, is for the sole purpose of reducing the suction on the road. This does not, however, prevent this same

shape being put to useful ends. In this case, the depth and width are sufficient to take an entire wheel (of the detachable wire type) complete with inflated tire. Back of this, as well as forward to the back of the rear seats, there is additional room for other things. On the side, it will be noted that the body is built out so as to cover the running board, thus giving the outside of the car an unbroken line from the front to the rear. The door over this side extension may be lifted off, when the tool box, suit cases, and other things become readily accessible. This gives more carrying space than the ordinary car full of people would need, as well as more than enough for the tools and mechanical parts, at the same time leaving the car with clean lines and no projections anywhere.

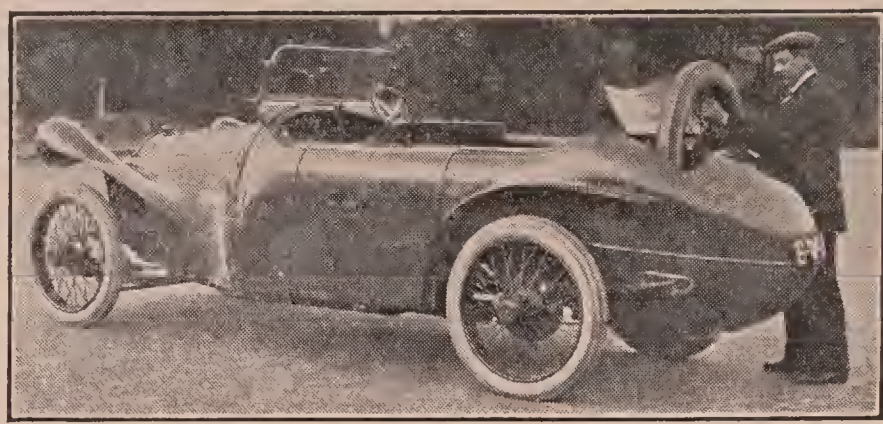

Fig. 153.—Quartering Rear View of Griffon (French) Body Developed to Eliminate all Suction at the Rear of the Body at High Speeds. The Novel Shape Is Put to Good Use, However, for Spare Wheels, Tires and Tools.

The only discordant note in this design consists of the freakish formation of the front ends of the fenders to form a holder for the searchlights. Viewed from either the front or the rear, these do not look attractive. It will be noted in this illustration how the proper construction of the body, along scientific wind-resistance-avoiding lines, does away with the importance of the fenders. In this case, the rears are simply narrow and shapely extensions of the body proper, while in front their principal function is to hold the lamps firmly and fill in between these supports and the frame.

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**THE FILLER PIECE** between the step of the car and the frame of body on it is now being made with a neat curve, either convex or concave. When the former is used, there is a considerable space back of this, and in length extending from the rear end of the front fender to the front end of the rear one. With any considerable wheelbase, this is quite long, and forms an excellent storage place. On a number of the 1914 cars, this is made in several compartments, each with a closely fitting and almost invisible door. In a few cases, this space is used for tools, in which case much longer and wider articles can be carried than in the conventional toolbox, in addition to which the latter is entirely eliminated. The net result is greater carrying capacity, superior appearance, one less place to catch mud and dirt, and to the manufacturer, at least, lowered first cost. Another firm—or, rather, several of them—use this place for carrying the batteries. As has been pointed out previously under the heading of Electric Lighting and Starting, this work requires a different form of battery from ignition. Consequently, when two different batteries are used, it becomes necessary to find considerable space in which to locate them. This new compartment fits in for this purpose very nicely, each side providing space for one battery and some tools, thus dividing the two different batteries to the two sides of the car, and placing the weight more equally as well.

Other uses have been found for this space as well, notably the storage of side curtains for tops, for parts of the tops themselves, for robes and similar bulky objects when not in use. In fact, in a dozen different ways this addition to the storage space on the car is found to be of use and extremely convenient.

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**THE DASHBOARD** has developed into another place, of great utility if not for actual storage. If Figs. 145, 146 and 147 be examined, it will be noted that the deep dashes of to-day have forced the use of what is termed an instrument board, for lack of a better name. This is a vertical board, usually of some ornamental wood, set at the edge of the dash nearest the driver, and projecting downward a sufficient distance to allow of fastening to it all the instruments used, all the control or adjustment parts not

placed on the steering wheel or post, the speedometer, the switches of the various light combinations, the lamp for illuminating the speedometer at night, and various other things. Since this requires a depth of approximately 8 or 9 inches, and since the depth of the portion of the sloping bonnet or filler piece between it and the actual dash line or the rear end of the motor compartment may vary from 10 to 18 inches, an odd corner is left. This has been put to excellent use by locating the gasoline tank there. Of course, it required a special tank, of an unusual shape, built, in short, to fill this exact space; but once the dies and tools were made for forming these, it cost the manufacturer no more than for a tank to go at the rear end of the chassis or under either the front or rear seats.

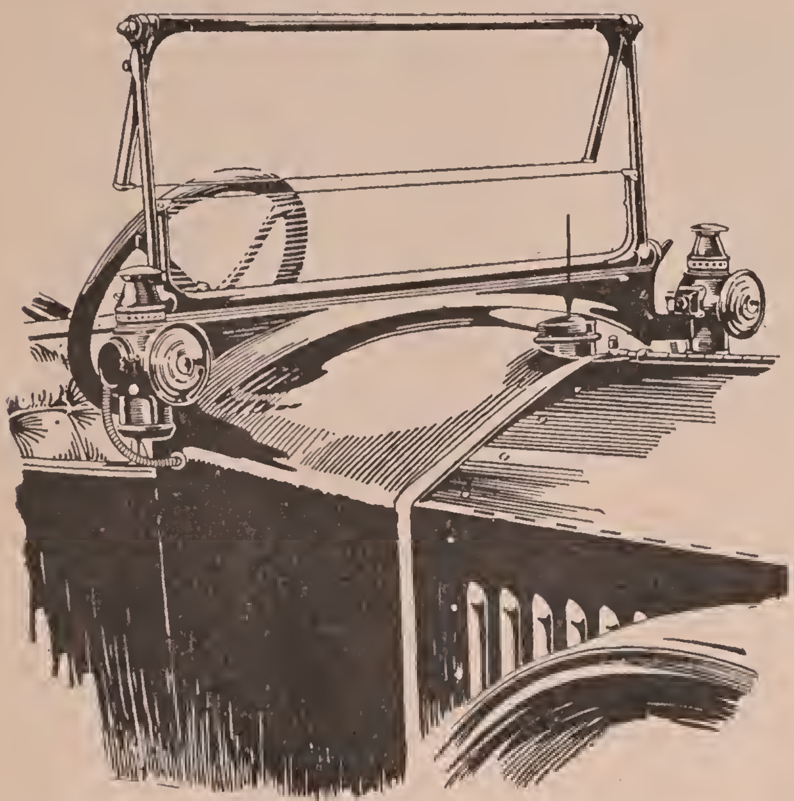


Fig. 154.—Dashboard Location of the Fuel Tank on the Hupmobile Has Many Advantages, Notably Certain Pressure on all Grades and Simplified Piping.

When one considers the width across the form of at least 28 to 30 inches, the width fore and aft of from 8 to 10 inches, and the depth limited only by the maker's idea of sufficient leg room, at least 12 inches being available in all cases, it can readily be seen that this formed a place for a fairly large and capacious tank. In addition, it could be filled from the outside at any time, without disturbing anything or anybody, and it keeps the fuel close to the carburetor, so that the piping is made very short, free from bends, and thus not likely to cause trouble at any time. In case of trouble, however, this piping was more simple to remove, clean, and put back than would be the case with the tank located anywhere else.

Another big advantage lies in the fact that the tank is directly above the motor and carburetor, so that a gravity feed is possible, no matter what grade the car may travel up or down, something which cannot be said of any other tank location. This insures the use of every drop of fuel, and does away with the possibility of fuel trouble on hills due to poor tank shape and location. Fig. 154 shows the exterior of a car with this kind of a tank, the arrow indicating the filling cap. If this were not used, how many persons would note the filler, so inconspicuous is it? In Fig. 155, a section is shown through the forward part of the same car, this indicating the location and shape of the tank, as well as showing the large filler cap and the relation of the tank's position to the sloping surface of the filler and the flat top of the bonnet, also the steering wheel and instrument board. This position of the tank has so few disadvantages, if any, and so many advantages that it is bound to grow in popular favor. Next year will see many more of the dash tanks in use.

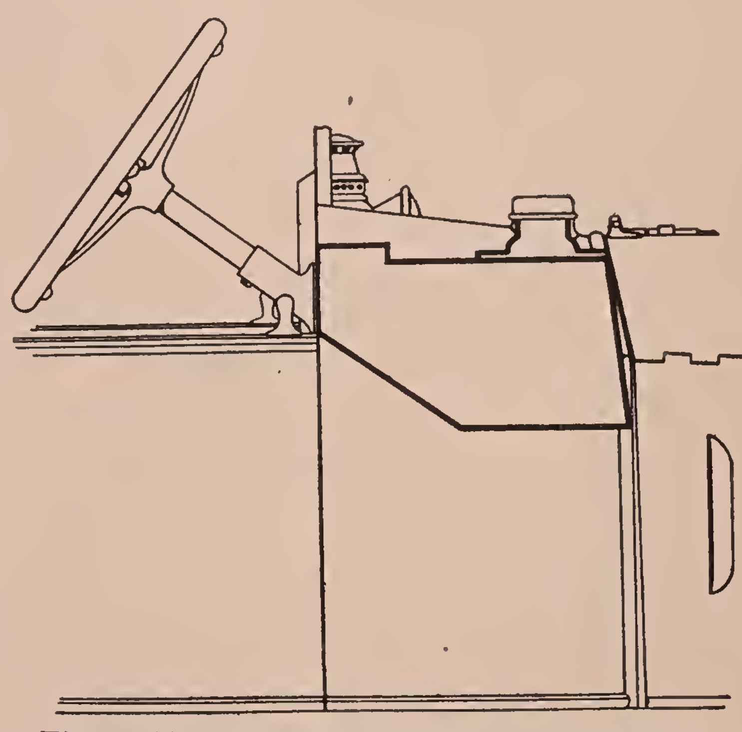


Fig. 155.—Section Through the Hupmobile Dash and Tank, Shown in Fig. 156, Indicating the Shape and Placing of the Tank Relative to the Other Parts.

When this type of tank is used, there are two restrictions upon it; one the need for a straight edge toward the driver in order to make a surface against which the instrument board will fit tightly, while its bottom line is limited by the space needed for the driver's fet. At any rate, it is possible to obtain a capactiy of ten to twelve gallons.

### TOPS AND TOP CURTAINS

have not kept pace with the improvements made in the balance of the car, although the last part of 1913 saw a great improvement in the design and construction of both. There were many complaints that side and other curtains were difficult to put up, and very slow as well, so that a person often got caught unawares in a sudden shower and got soaked through putting up the curtains, even though the top was up to start with. Following these complaints, a number of successful forms were constructed and applied to tops, which with the top up could be pulled down into position about as rapidly as ordinary house shades. These, however, required a special construction of top, consequently were not applicable to the forms in use, without considerable expensive alteration.

Next, forms were developed which were not open to these arguments, consequently the curtain situation may be said to have been simplified to a large extent. In the way of tops, those for runabouts gave little trouble, but for touring car tops, particularly the unusually large and long cars now being constructed, putting up a top was a two and in some cases a three-man job. The first effort to simplify this consisted in the use of bars, which were applied to the side of the car first, and then the top applied to these. In this way, it was possible for one man to put up or take down the largest tops, but the bars were long, difficult to handle, and many persons did not like them.

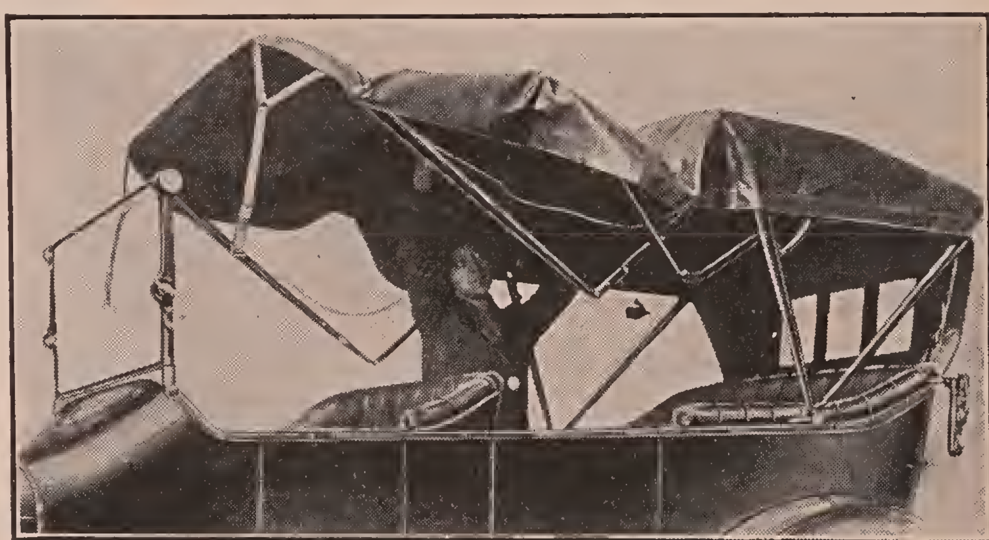


Fig. 156.—Sharrer One-Hand or One-Man Top, Indicating How It Is Possible for Any One Person to Raise This in a Short Time and Without Assistance.

With the ideas gathered from the use of these, top makers have now produced tops for touring cars which one person can put up with ease in a few moments. These differ from the older forms in having a pair of extra long bows in front, the irons of which fold in the middle so that the top, when folded up, requires no more space than the older forms did. When these are extended, however, the whole front of the top is supported from the iron on the rear seat. In short, there is no iron on the front seat, the long bows of more than double the previous greatest length taking care of the front support. By doing away with this iron and the necessity for lifting the top bodily from the back to the front seat for the purpose of making connection with it, the operation of putting it up or taking it down has been simplified materially, and made easy to handle.

In order to limit the movement of the front end, when putting it up, and to render the whole more stable when up, a stout but very small wire is incorporated in the construction, so that even if the rear end is put up first and then the front end dropped, it must open out in the correct manner, and no harm is done. A further simplification and a most desirable one is the doing away with the long, awkward and unsightly-looking straps formerly used to support tops, these being run down to the very front end of the main frame, in some cases even farther, to the forward spring hangers. In their place, a very short and strongly built strap is run to a portion of the built-in windshield or of the sloping upper surface of the bonnet. The building in the windshield as a component part of the car, instead of applying it as an afterthought, as was the case in former years, has done much to make changes like this possible; with the former construction, the shield and dash construction were not sufficiently stable to form a good place for attaching a top strap.

The form shown is but one of the many one-man tops now on the market or used on the best cars. For 1914, it is surprising how many of the makers have included this accessory, while it promises to be even more general in 1915.

**SIX-CYLINDER MOTORS** have made tremendous strides in the past few years. Although brought out as long ago as 1907, they attained very small proportions in the industry until 1910. In that year, the previous small number of makers who were turning out this type exclusively, having abandoned fours, was augmented by several of the manufacturers generally rated among America's best. This was sufficient to turn the tide in favor of sizes, and to-day there are very few high-grade makers who have not at least one six, the same being true among the medium-grade machines listing above $1,800. Moreover, among the very best makers, there is to-day a very small number not making sixes exclusively. This is but another way of saying that the highest-grade firms, after trying out the six for several years, have abandoned fours in favor of the six.

What is the reason for this movement? It cannot be summed up in a few words, but from a mechanical standpoint, the six-cylinder engine has a superior balance—that is, there is no time in the complete cycle of events when there is not a propelling impulse being given to the crankshaft. In the four and all smaller numbered cylinders, there is a point—in fact, there are several points—in the cycle when the cylinders are not putting forth a propelling impulse—that is, when the crankshaft is being driven through the energy stored in the large rotating mass of the flywheel. By way of stating this fact in another way, it may be said that this is what the flywheel is for, so that the more even turning effort of the six makes a flywheel less necessary.

As a matter of fact, some of its more rabid adherents claim this as one of its advantages, and an English firm, devoted largely to the six, several years ago constructed one without a flywheel and drove it several thousand miles in all kinds of traffic for the purpose of proving this particular point. At slowest speeds, it is desirable to have some such source of energy, however, and engines, even the most perfectly balanced sixes, will always have flywheels. The more perfect balance and more evenly distributed turning effort allow of the flywheel weight being less than a four-cylinder motor of equal power, hence some weight is saved to offset the greater weight of the engine itself.

Since the power production of the engine is more even and regular, with a continuous turning effort throughout the cycle, it follows that a very much smaller size may be used to produce the same power as with a four. Besides reducing cylinder sizes, the individual impulses or explosions are not so violent, consequently the wear is less and the noise of each power-producing explosion is smaller. Consequently, it is claimed with good logical reasoning that the six is more quiet and will have a longer life.

Since the power impulses of the six overlap so that there is a continuous production of energy, with no gaps in the cycle, it is claimed that the six is more efficient. As a consequence of this, it is claimed further that a six will develop more power in proportion to its size than a four of equal cylinder capacity—that is, for instance, of a bore 50 per cent. greater and equal strokes. At any rate, the advocates of the six credit it with better hill-climbing ability, and if not greater speed at least with easier and smoother riding at equal speeds.

With the matter of tires, it is said that the smaller individual power impulses, coming more evenly and overlapping, turn the wheels continuously and more regularly, consequently the tires are jerked less at starting and whenever increasing speed. This being the case, there is considerable logic in the claim for a longer life of tires under a six than under a four of equal power rating and equal weight. Moreover, it is claimed that this same jerking, which does much to wear out tires, wears out the roads, so the sixes are credited with being easier on road surfaces as well.

Against the six, it has been claimed that the fuel consumption would be greater as well as that of oil. The adherents of the six refute this, on the ground that the fuel consumption is governed by the cubical capacity of the engine as a whole and its efficiency, also as a whole. If for equal power development, the six may have a smaller cubical capacity and show a higher efficiency, they say, it

follows that its fuel consumption will be less instead of greater. Similarly with lubrication, they say this is proportional to the surfaces in contact and the speed at which they travel. If these surfaces are less, and the engine rotates at a much lower speed to develop the same power, it follows that the lubricant used on a six will be less instead of more than a four of equal power.

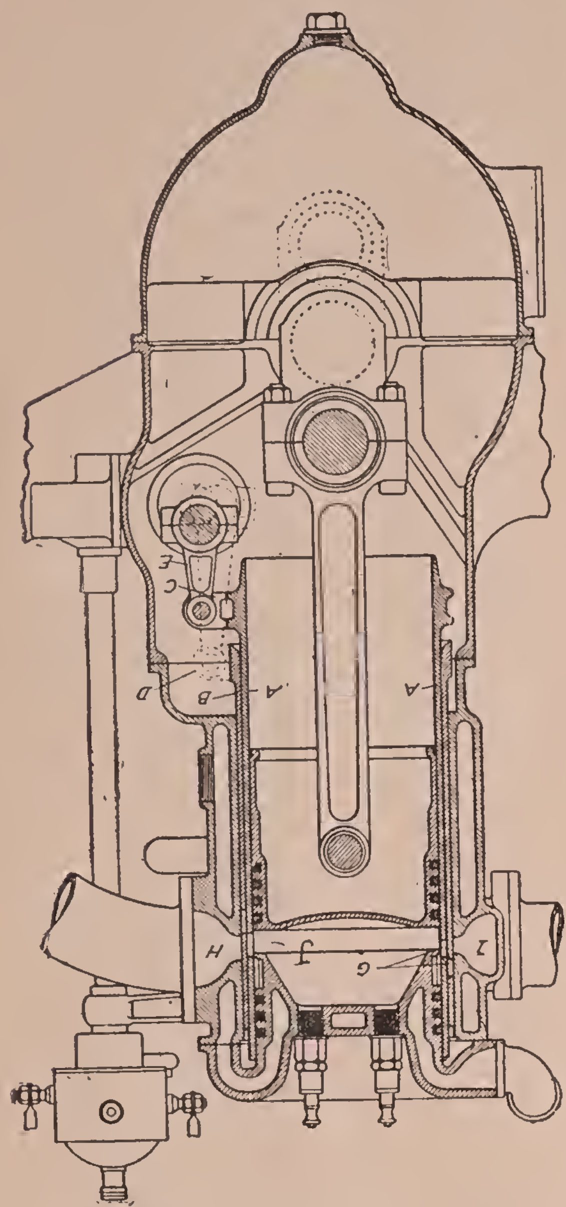
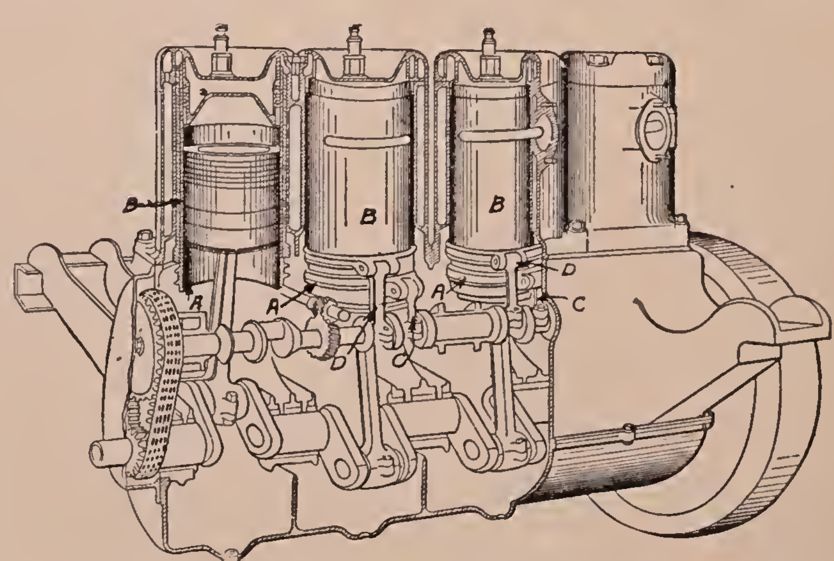


Fig. 157.—Section Through the Knight Sleeve Valve Motor, Indicating the Two Sleeves Which Replace the Valves, and the Eccentrics Which Drive Them.

Other points which are brought out in favor of the six are the absence of vibration, and the lessening of gear shifting through the ability to accelerate or decelerate the engine more quickly, easily, and with less possibility of the engine "knocking." In the matter of vibration, even though this be slight at low and moderate speeds, at high rates of revolution it is considerable, and quickly tires the driver as well as anyone traveling in the car. Many persons are wholly unconscious of the reason why, but know that on certain cars they feel tired after a comparatively short ride. This is the result of excessive vibration.

Since there is less in a six than in a four, due to more perfect balance, overlapping power impulses, and no dead center points, this must be more easy and comfortable to ride in, whether for a short or a long distance. More and more people, particularly American people, are getting to the stage where they demand a one-speed car—that is, one of such a design and construction with such a quantity of power as to be able to accomplish everything upon the one speed, and that the high speed. This is what has produced such a great increase each year in the size of power plants, until to-day by comparison with the product of other countries American cars of any given size have a larger motor and a greater power production than the same size car from any other country.

In this respect, however, the six has been somewhat of a boon, for its very flexibility, its lower slow speed and its higher high speed, its quick acceleration, and other qualities have combined to make it an excellent one for the man who refused to change gears except when it was an absolute necessity. Many skilled drivers of sixes, knowing their motors well, are able to start off on the high or second gear, such is the ability of the six to pick up speed very rapidly, while the lack of any dead points in the cycle lessens the chances of stalling the motor, even though it be somewhat overloaded momentarily.




158.—Another Knight Sketch, Indicating the Silent Chain Which Drives the Eccentric Shaft. This Shows Also the Working of the Sliding Sleeves.

A list of the makers, showing the production for 1914, indicates that no less than 47 will list sixes, while in 1913 there were but 26; in 1912, only 15; in 1911, but 11; in 1910, 9, and in 1909, 8. Of the 8 in 1909, just two will continue to build fours in 1914, while of the 9 in 1910, all but three have abandoned fours for good. Considering the 11 of 1911, but four of them are still making fours, while of the 1912 group of 15, all but five have given up the smaller number of cylinders in favor of the

smoother running six. These figures, showing what the foremost manufacturers in the automobile industry think of the six, as reflected in their own manufacturing plans, is perhaps more conclusive than anything else that might be said.

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**SLEEVE AND ROTARY VALVE ENGINES,** of which there is a multitude since Knight of Chicago made such a success of his sliding sleeve valve engine, and showed the world (at that time very much inclined to doubt its ability to run, to say nothing of competing with the then universal poppet form) that he had a very superior device. With the adoption of this by the best firms abroad, following long exhaustive tests of all kinds, Knight came into his own, and to-day the licensees under the Knight patents include the best cars, notably the English Daimler, Austrian Diamler, Minerva (Belgium), Panhard (France), Mercedes (Germany), and in this country Stearns, Lyons, Edwards (now Willys-Knight), Stoddard-Dayton, Columbia (now out of business), and Moline.

Following the great advance in quiet running which the first Knights showed, there was an instant rush toward that type of motor, followed in turn by a rush of inventors into other engines in which the conventional poppet valves and rotating camshaft were replaced by some form of disc, sleeve, or piston, either reciprocating like the Knight sleeves, or rotating; in short, any kind of a construction in which the camshaft and poppet valve arrangement were eliminated.

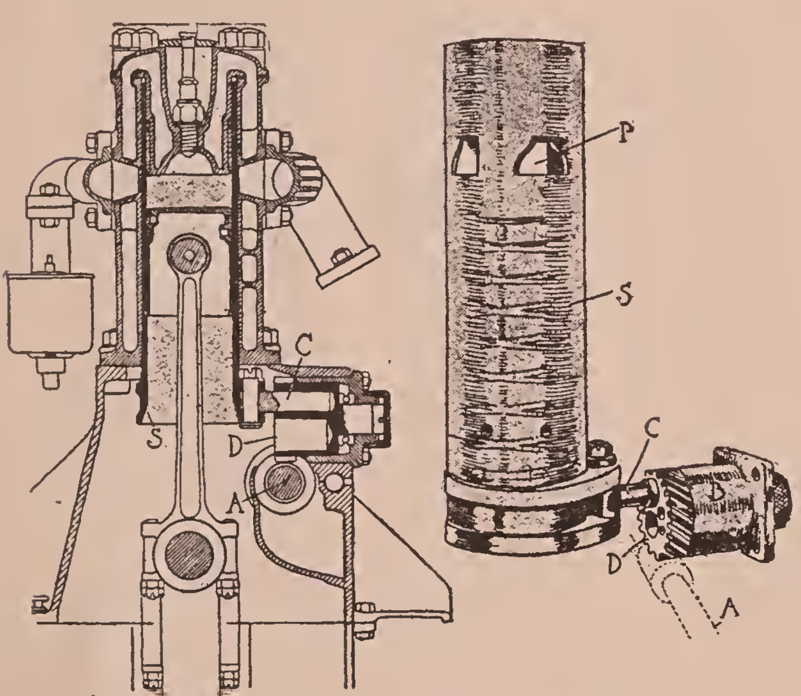

Fig. 159.—The Argyll (Scotch) Single-Sleeve Valve Engine, in Which the Use of an Eccentric Pin Oscillates the Sleeve Back and Forth Around the Piston.

Naturally, not all of these were successes—in fact, the majority were failures—so that following the first rush into a non-poppet form, there was a later equal rush back to it. In the intervening two or three years of time this movement occupied, the poppet type had been simplified materially, silenced so as to be as noiseless as it is practicable for mechanism, while improved design gave the flexibility higher speeds and greater power outputs, which at the time of the first Knight tests showed so poorly by comparison with the new form.

As soon as a perfected engine of the Knight type had been turned out at the Coventry works of the Daimler (English) Company, this was placed with the Royal Automobile Club of Great Britain for a thorough test. In this, the engine performed unusually well, the larger four-cylinder engine of 124 millimeters bore and 130 m.m. stroke (4⅞ by 5⅛ inches) rating at 38 horsepower delivered an average of 57.25 horsepower for 15 minutes, a minimum of 50.8 horsepower, and a grand average of 54.3 horsepower during 134 hours and 15 minutes continuous testing, or more than 5½ days. After this, the engine was put back into its chassis, and then the car was run for 1,930.5 miles on Brooklands track, at an average speed of 42.4 miles an hour, followed by a run of 229 miles on the road.

During the first bench test, the motor averaged .679 pints of fuel a brake horsepower-hour, and in the final bench tests but .613 pints. On the track, the car averaged 20.57 miles to the gallon (Imperial), and on the road, 19.48 m.p.g. The car weighed 3,805 pounds on the track, and 4,085 on the road tests. At the same time, a smaller motor of 96 m.m. bore and 130 m.m. stroke (3 25/32 by 5⅛ inches) did equally as well, averaging 38.83 horsepower throughout 132 hours and 58 minutes, practically 133 hours. In a car weighing 3,332.5 pounds on the track, it ran 1,914.1 miles at an average speed of 41.8 m.p.h., and then, weighing 3,612.5 pounds, did 229 miles more on the road. In the road work, it averaged 19.48

miles to the gallon, and on the track, 22.44. After these most unusual results, which have not, as a matter of fact, been surpassed right up to date, the engines were dismantled and inspected thoroughly, but not a sign of failure, undue wear, heating or anything else could be found; in fact, the tool marks were still visible on the sleeves forming the valves of the engine.

After this test, the Knight engine may fairly be said to have established itself, and previous arguments against it of inability to lubricate the sleeves and pistons properly, and others, were silenced. From that day to this, the motor has advanced steadily, until it might almost be said that its adoption by all the best makers is only prevented by the attitude of its inventor toward the wholesale issuances of licenses. To revert to the engine itself, the construction is shown in the sectional view of a cylinder seen in Fig. 157. In this, it will be noted that just outside of the usual piston there is a long sleeve marked *A*. Outside of this, in turn, is a second shorter sleeve marked *B*. These are moved up and down—that is, reciprocated, by means of eccentrics and rod connections, the eccentrics being upon a rotating shaft at the side of the cylinders and within the upper part of the crankcase. The pair of these shown are marked *C* and *E* for the *A* sleeve, and *D* for the *B*.

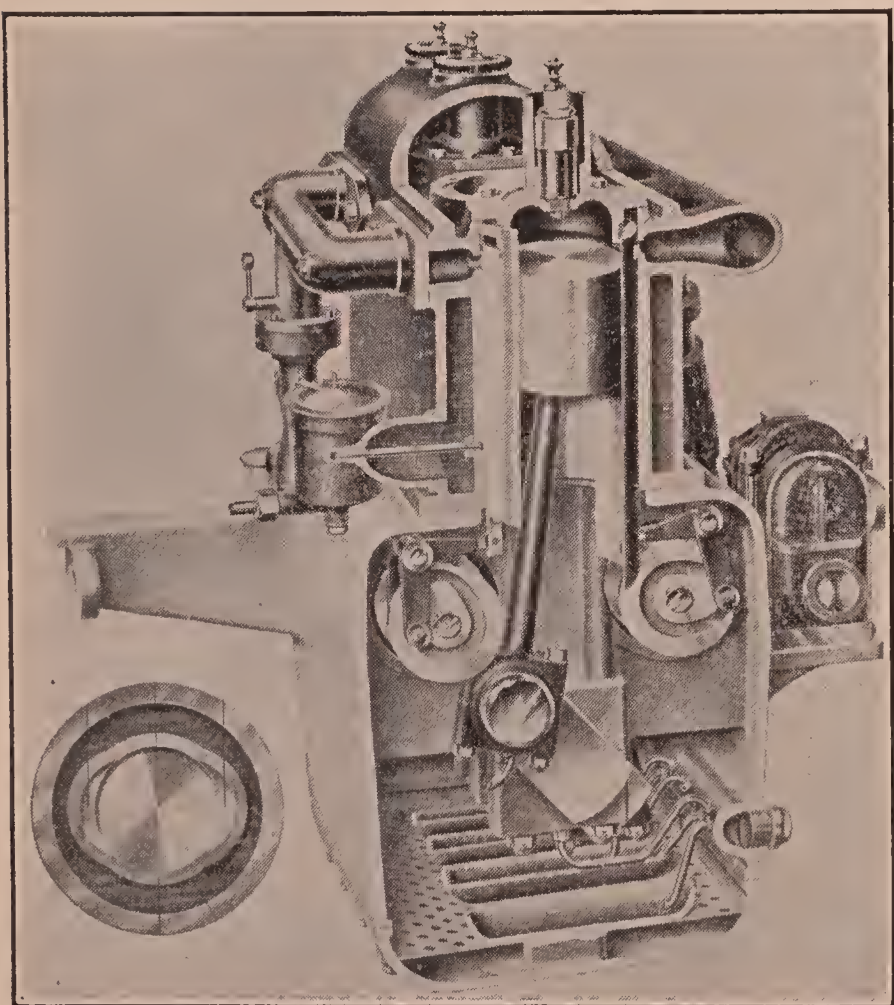

Fig. 160.—The Magic Motor, in Section, Showing the Sliding Crescents on Either Side of the Piston Which Replace the Usual Valves.

The shaft corresponds very closely to the usual camshaft, but, as first brought out, it introduced one feature, which has since been found applicable to all engines and has been adopted widely, namely, the use of a silent chain for driving this shaft from the crankshaft. This in itself is not unusual, but it introduced a freedom of position not hitherto known, for it allowed of placing the camshaft (in this case, the eccentric shaft) in any desirable position, instead of the former necessity for locating it at the point which the gears needed for its drive fixed. As Fig. 158 shows, the chain is placed at the front end and entirely enclosed. In this sketch, the parts are marked the same as in Fig. 157, so that the one may be referred to as readily as the other.

In the upper parts of these sleeves, there are two sets of ports cut on the opposite sides of the sleeves, not of the same height, nor of equal widths. The arrangement of the eccentrics, these port holes, and the lengths of the sleeves is such that at certain points in the stroke, the two openings *G-G* on one side of the piston—that is, on the inlet side in this case—register exactly, so that a comparatively large opening is formed connecting the inlet pipe *I* with the interior of the cylinder at the time when the piston is beginning to travel down and consequently is beginning to suck in a fresh charge. The continued motion of the sleeves, brought about by the rotation of the eccentric shaft positively driven from the main engine shaft, cuts off this opening at the conclusion of the suction. At this time, the piston begins to rise again and the sleeves do not expose an opening, but at the conclusion of the expansion following the firing of the charge by the usual spark plugs, the openings *J-J* on the opposite or exhaust side of the sleeve begin to register with the exhaust-pipe opening *H*, thus permitting the burned gases to pass out.

At times, the sleeves are moving in opposite directions, which makes for a very quick opening, one which reaches its maximum in a space of time much shorter than is possible in any other form of engine. For this reason, it is claimed that greater power outputs are possible. The same is true of quick closing in those cases where it is desirable. It is claimed for this type of motor that a longer inlet opening is possible, thus giving the motor more gas; also, that a shorter exhaust opening will serve to clean out the cylinders more effectually, both of which contribute to greater power output, as well as superior economy.

Among the other claims made for this type of motor are: Exactly accurate and consequently equal combustion chambers. In the ordinary engine, it is almost impossible to obtain this, due to the roughness and inequality of cast iron and the irregular shape of the combustion chamber. This makes for more even and regular power impulses from each cylinder, and thus a more smooth-running engine; better shaped combustion chambers—that is, with theoretically better shapes. The best shape in the poppet-valve type of engine is the one with overhead valves, seldom used because difficult to design, construct and operate; straight line inlet and outlet, permitting easier gas flow without the friction set up at all bends and angles of the pipes. In the one case, this reduces the inflow of gases, and in the other it restricts the outflow of burned products; as the sleeves and piston wear smooth and to fit one another, the engine runs easier, more quietly, and gives greater power. With the poppet valve form, the opposite is true, as the engine wears, the engine does not run as easily, is more noisy and loses power. Most of the other claims made are based upon these or combinations of them.

# CHAPTER X.

# The Newest Tendencies in Construction.

**OTHER SLEEVE AND PISTON VALVE ENGINES** have been built to produce these same results, but in a slightly different manner; thus we have single-sleeve reciprocating forms, in which the one sleeve is so arranged with its ports and drive as to do everything that Knight's two do. Then there are single-sleeve forms which rotate, others which oscillate—that is, rotate part of a circle, and then rotate in the opposite direction for any equal travel. Still others have a pair of semi-circular discs, partial sleeves, or crescents, as they might be called, working on opposite sides of the piston in special slots cut into the cylinder walls.

Furthermore, there are the many piston forms, as, for instance, the piston replacing the poppet valves (two for a cylinder replaced by one piston) and performing their work in a similar separate chamber parallel to the bore of the cylinder (The Miesse engine). Another is the Hewitt, in which a pair of pistons working on an inclination replace the ordinary valves, one being equal to the inlet valve complete, and the other performing all the duties of the exhaust. Another form has pistons which rotate, these being arranged so as to uncover and cover ports in various points of the revolution.

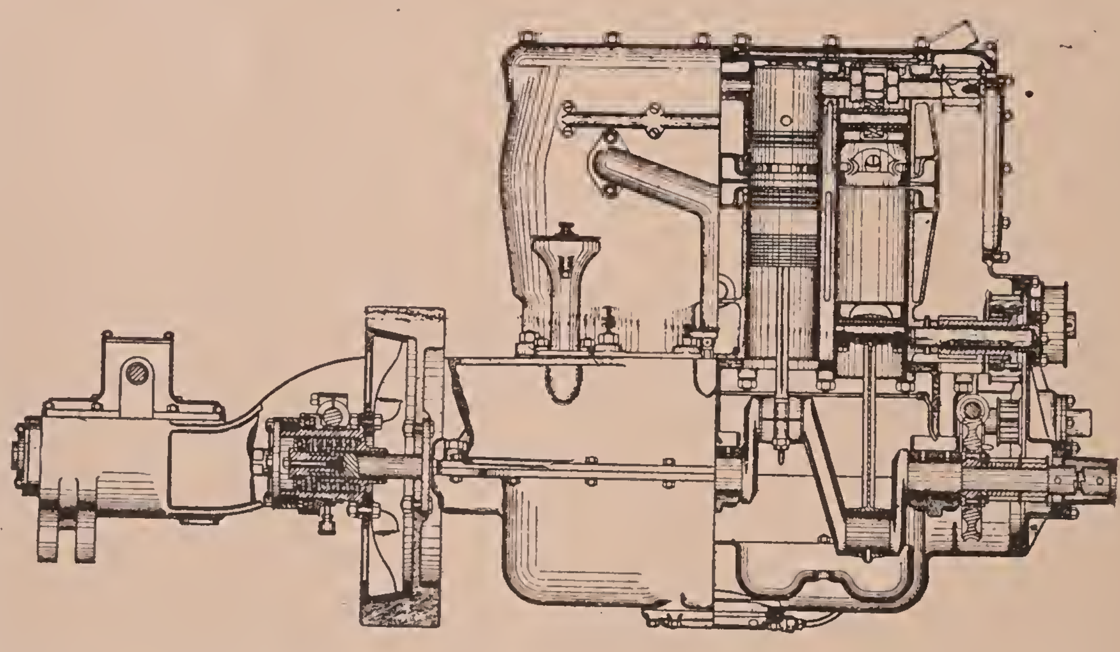

Fig. 161.—The Carter Piston Valve Engine, in Which a Piston Sliding up and Down in an Upper Extension of the Cylinder Serves as a Pair of Valves to Admit Gas and Discharge the Exhaust.

In the Carter (American) piston valve form the piston valves reciprocate, but are placed within the cylinders in a special extension of the bore and directly above the usual working pistons. As Fig. 161 shows, the pistons are moved by means of cams, placed on a camshaft which is set lengthwise of the top of the cylinder head, but entirely enclosed within it. This shaft is driven at the front end by an enclosed silent chain from another shaft, which in turn is driven by silent chain from the crankshaft. This is required in order to get the big reduction needed, as the piston valves have a total movement of but ½ inch or ¼ inch in either direction.

The two ports are extremely narrow in themselves, but extend entirely around the cylinder except for a very small space for the split in the compression rings of the piston valves. By comparison with a poppet valve of equal bore (3¾ inches) the former had a valve area of 2.06 square inches and the latter 1.75. However, the latter had a quicker opening amounting to but 60 degrees of rotation on the flywheel, while the poppet type took 102. Moreover, at the beginning of the opening, the piston showed a valve area of four times that of the poppet.

The necessity for getting a full charge of gas into the cylinders quickly is too well known for its favorable influence on power, economy, speed, and other qualities for this to need further explanation.

In the Sphinx engine, this piston is replaced by a split ring, set into the top extension of the cylinder bore, and reciprocated by means of lever attachment to a cam on a rotating shaft. This has many of the advantages just named, and is very inexpensive to build.

**RING AND DISC VALVES** come next in popularity by inventors, these including all the rotary, reciprocating, and oscillating rings, discs and cylindrical sleeves, not previously mentioned. The Reynolds engine, invented by a Detroit man, and developed by interests very close to the Hudson Motor Car Co., is typical of these. This is shown in Fig. 162, where it will be noted that the valve consists of a round, flat disc in which a large port is cut. This disc is connected by means of a short, vertical shaft with a gear in a second separate chamber above the piston space, this meshing with a driving pinion on a vertical driving shaft on one side, in the case of the first cylinder, and with the gear for the second cylinder on the other side. The four gears for four cylinders thus form a continuous train, so that all are driven at the same speed, but every other one in the opposite direction.

As will be noted in the figure, also, there is an inlet passage for the fresh gases from the carburetor on one side and another for the exhaust on the other, the two being separated by a wall of metal so that by no possibility could they be connected. In the bottom part of each of these passages, there is cut a port which corresponds in size and location with that in the valve disc. Thus, when the rotation of the latter brings it directly below either of the other openings, a clear port through from the inlet passage to the combustion chamber in one case or from it out to the exhaust passage in the other, is formed. This form gives a completely machined combustion chamber, and has many of the advantages of sleeve forms previously mentioned.

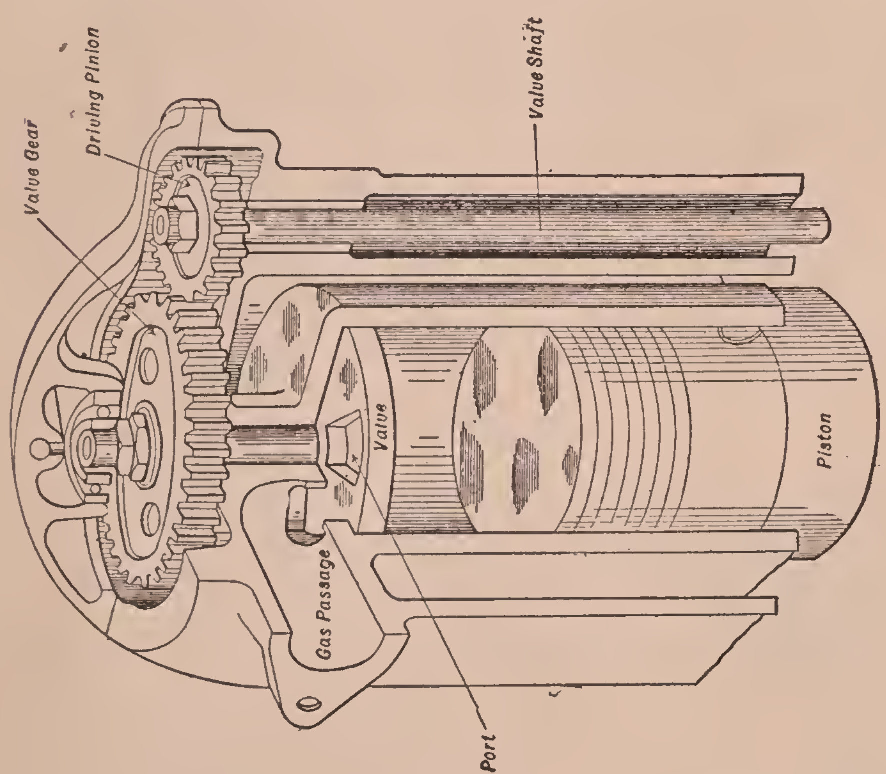


Fig. 162.—Sketch Depicting the Method of Operating the Reynolds Disc Valve Motor, and Indicating Also the Method of Driving the Discs by Vertical Shaft.

Along practically the same lines is the cone type of rotating disc. In this, the disc, instead of being flat, is cone-shaped, and has the ports cut into the sloping faces of the cone. The top of the cylinder is coned to match it, while the passages from carburetor and to the exhaust are set up at a greater height on the cylinder and open in at a right angle to the face of the cone valve. This has an advantage in that it narrows up very materially the total width of the cylinders, making it more compact. This same idea is carried out in a similar double type, in which two single-ported cones are superimposed one upon the other. To offset the disadvantage of doubling the number of parts, it is said that this makes a construction which is tighter—that is, more "gas tight," so that there is no loss of compression—while the double disc use gives a sharper cut-off, both at opening and closing.

An engine is constructed also in which a pair of the cone-shaped discs is used to take the place of the usual two valves—that is, each disc takes the place of one valve and performs its functions. This is not as complicated as it sounds, but it has the disadvantage of making the valves smaller; in the former type, they

can be of a diameter equal to that of the cylinder, and due to the cone shape of a greater surface than a flat disc of equal size with the pistons. With two of them placed side by side, however, the size of neither can be quite half the cylinder diameter. Just as the size of the valve is reduced, so the size and effective areas of the ports cut in them must be cut down.

Several years ago, the Elmore two-cycle engine was improved with a cylindrical, hollow distributing valve, set lengthwise of the cylinders, and rotated by means of gearing. This engine is no longer manufactured, but this principle of a valve has been applied to a number of different motors, notably the Mead (American), in which a pair of distributing rotary valves is used; the Darracq (French), in which but one is used; the Itala (Italian), in which one set vertically is used for each pair of cylinders, so that but two are used on a four-cylinder motor, and others.

The Mead is the most interesting because it is used in the Speedwell cars. A section through an engine of this form is shown in Fig. 163, this showing how the rotation of the valves puts the combustion chamber in connection with the carburetor and the exhaust pipe at the proper points in the stroke.

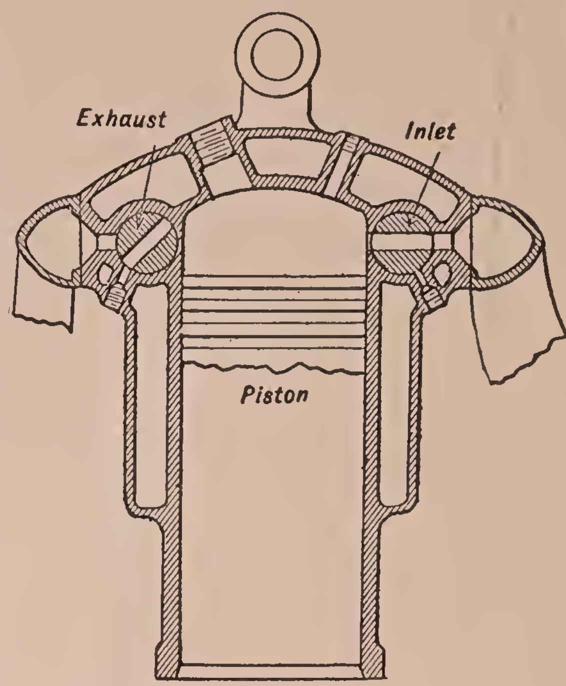

Fig. 163.—Sectional Sketch Through a Cylinder of the Mead Rotary Valve Engine, Indicating the Two Valves on Either Side of the Upper Part of the Cylinder Walls.

There are numerous other different engines which would come under the general heading of sleeve, disc and piston valves, some of them offering much promise, but space will not permit a description here.

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**GEAR-SHIFTING DEVICES,** electric and pneumatic, represent the latest idea in the elimination of mechanical effort on the part of the driver while operating the car. How successful these will be cannot be told at this time, for they have not been in use a sufficient length of time to bring out any disadvantages or flaws in the construction. Four or five of the best American cars have adopted the electric form, supposedly because of its superiority; but doubtless the fact of having a current generator on the car had much to do with it.

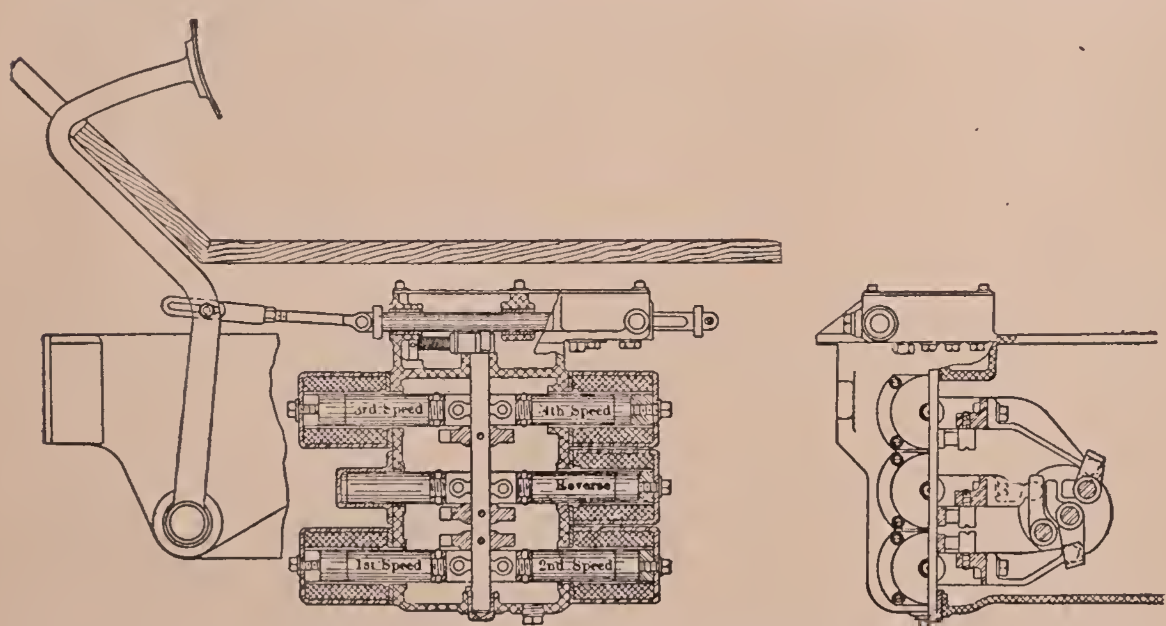

Fig. 164.—The Vulcan Electric Gear-Shifting Device, Showing the Solenoids and Plungers Which Move the Gears When the Current Is Applied.

A section through the form of electric gear shift, as used on the S G V car, is seen in Fig. 164, while 165 shows the hand wheel with the row of buttons which displaces the usual lever. In order to get any speed, it is necessary only to press the proper button, and then press the clutch pedal away out, and immediately let it in again. The buttons are six in number for the four forwards, one reverse and neutral. The other two buttons indicated are for the horn and magneto cut-out and have no connection with the gear-shifting device.

The principle of the latter is that of a solenoid, operating each gear and connected with the source of current only when the button is pressed. As long as

the clutch is in, nothing happens, but as the clutch is fully disengaged, it closes a knife switch, and thus sends the current through the particular solenoid that has been placed in the circuit by the button. This solenoid then places its gear in mesh, ready for action when the clutch is re-engaged. From this it may be seen that the actual electric shifting of the gears does not start until the clutch has been thrown out, and is concluded between that time and the moment when it is again fully engaged.

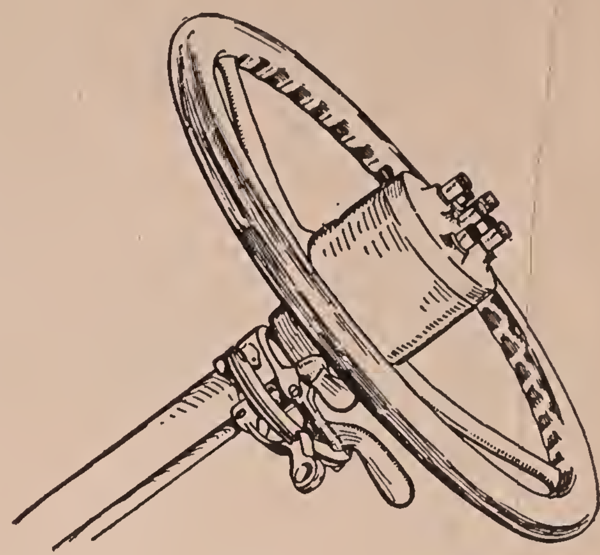

Fig. 166.—The Steering Wheel of the Haynes Car Which Uses the Electric Gearshift, Indicating How the Push Buttons Are Arranged.

It is claimed that the solenoids exercise a pull of 150 pounds, which is sufficient to engage any gear immediately and positively. Despite the large pull exerted, it is said that the current consumption is small, 300 shifts taking less than starting the motor once.

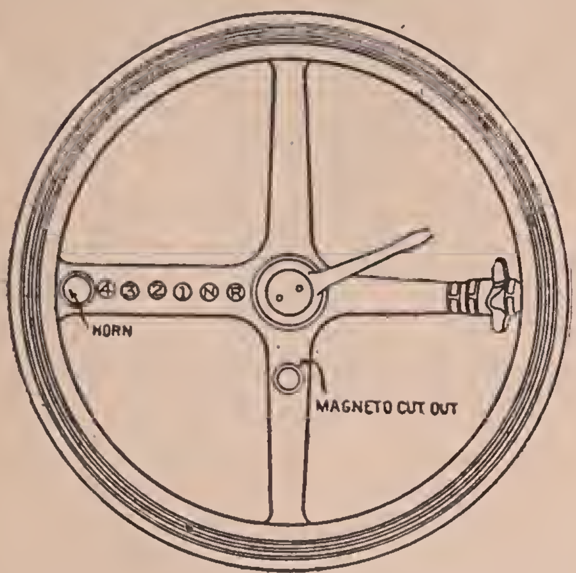


Fig. 165.—The Steering Wheel of the S G V Car, Showing How the Electric Gearshift Is Operated on That Make.

Engagement of two gears at once is provided against by drawing all into neutral before making any shift. Stripping gears through shifting while the clutch is in is impossible, for no current can pass until the clutch is thrown out. As a further provision against mistakes or troubles, an interlocking device is connected with the buttons so that it is not possible to press two of them down at once.

It is said that the total weight added to the car is but 46 pounds while the advantage of doing away with a lever and thus making the car accessible equally from either side is worth as much as that. In addition, such a device makes driving safer, for the hands need not be removed from the wheel for gear shifting.

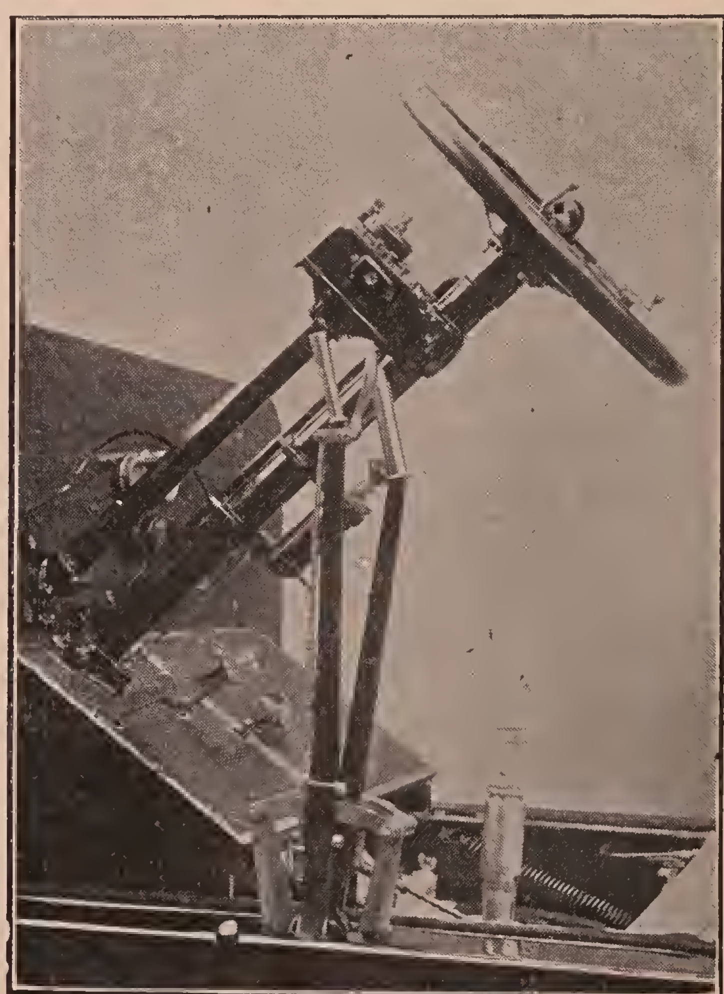

Fig. 167.—Control Group on the Packard Sixes, Indicating the Box by Means of Which all Electrical Operations Are Governed.

The same device is used on the Haynes car, but the arrangement of the buttons is decidedly different. On that car, they are bunched up around a circular boss in the center of the steering wheel and raised somewhat above it. This arrangement with the horn brings the grouping to be noted in Fig. 166. Another and a different arrangement is used on the Norwalk car, in which the row of buttons is in a long line, as on the S G V, shown in Fig. 165; but the row is placed below the steering wheel; on the post, in fact. It is, however, carried out far enough so that it may be reached by the fingers without removing them from the rim of the wheel. This would appear to be at a disadvantage as compared with the other two, for the button pressed is not visible, and can be seen only by leaning over to one side.

The tendency in this arrangement is to bring everything which must be operated or controlled to one point, and that a point very close to the driver's hands, and exceedingly accessible for him. Some-

what the same idea is worked out on the 1914 Packard cars, in which a control box, placed on the steering post just below the steering wheel, gives control of all the lights, the electric system, including starting and ignition, and every other unit in the control system, excepting only the gear shifting and the brakes. A view of the control group of a 1914 Packard, as in Fig. 167, shows this plainly.

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**THE ALL-ELECTRIC CAR** must be considered when the wonderful advances made in electrical devices for the motor car are considered. A form in which the transmission was displaced by a dynamo, and the clutch and flywheel by an electric generator, was brought out by the Columbia firm several years ago, but this was too far in advance of the times, and, being poorly received, was withdrawn from the market. There are signs, now that Columbia is out of business and electricity has become deservedly popular and widely used for motor cars, that this form will be revived. The usual speed lever was replaced by a smaller and shorter one, which could be placed in any desired position, alongside of the seat, on the dash, on the steering wheel—anywhere, in fact. This did not have the usual three or four speeds, but allowed about six or seven in both directions—that is, seven forward and seven reverse. Furthermore, by adding slightly to the wiring, this number could be extended indefinitely up to, say, 20 or more speeds in both directions. At least one brake and possibly both could be eliminated, for the drag of the motor armature could be used as a brake much more efficiently than any mechanical form, capable of much quicker and more effective application, and operated by the same lever as the speeds.

Since the generator armature replaced the flywheel and clutch, while the dynamo or motor displaced the transmission, there was a very slight increase in weight—say, not to exceed 250 pounds over the same car with a mechanical clutch, transmission, brake operation, etc. What was lost by the additional weight of these units was gained back partly by the saving of weight in brake parts, operating rods, levers, bearings, etc., including, of course, gear-shifting rods, levers, etc. From the operator's standpoint, this had many valuable advantages over any car now on the market. The arrangement of motor and generator provided a starter, under present arrangements would give current for all lights (electric lighting for motor cars was unknown at that time), gave many times as many speeds as are now available, simplified control, a lessened number of parts with consequently less opportunity for wear and noise, gave a more efficient drive than the present mechanical form, so that economy of operation would result when it was fully developed, while the unusually numerous speeds, one for every possible contingency, would make for economy of operation as well, and many other advantages.

In giving thought to these, and their value to the motor-car owner and operator, looking at the subject, of course, from the standpoint of what present-day cars offer and what present-day owners demand, it would appear as if the all-electric—or, more correctly, the gasoline-electric—form of car is more than a possibility, it is a comparatively near probability. The coming of the electric transmission with gasoline motor drive will force many changes, now unforseen, in cars which do not use it, in order to be able to compete with it.

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**WORM GEARING** has come to the front very rapidly in the improvement of modern motor cars and the gradual perfection of their detail parts. A few years ago, say five, it was admitted that the worm gear had many advantages, such a great reduction in speed for very small sizes, quiet running, and others, but its efficiency was considered to be very low, in addition to which it was thought that taking up the thrust of the worm action required unusual bearings, making an expensive construction, while the small use of worm gears, making very few of them to machine, ran up the expense of constructing them.

They had so many advantages, however, that a few brave spirits insisted on using them, notably Dennis, the famous English motor truck builder. For his work, where a great reduction of speed between the motor and the rear wheels, and preferably between the transmission and the wheels, was necessary, he found them excellent. By using them continuously, he disproved the assertion that they had a short life, and proved on the contrary that they had a very long life. Furthermore, he found that their silence and efficiency improved with use—that is, the longer they were used, the more efficient and quiet they became. He disproved another mooted point, also, namely, that they were difficult to lubricate, finding this a most simple matter.

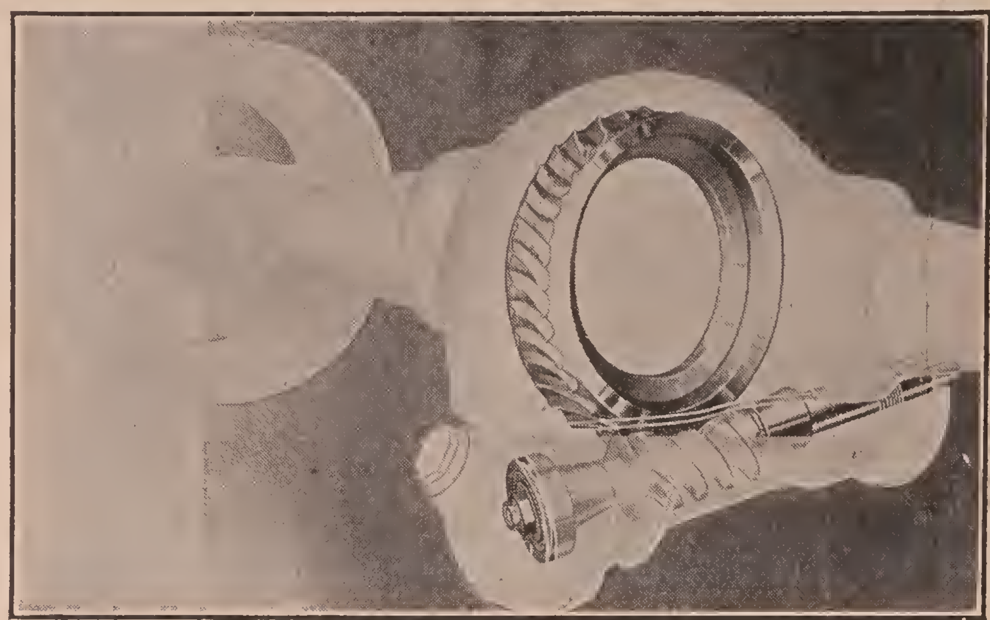

Fig. 168—Worm-Driven Rear Axle Used on the Detroit Electric Cars, Indicating the Location of the Worm Below the Axle, the Best Position for Easy Lubrication.

As he continued to use them year after year, and to use a greater number each season, he found that their first cost of cutting and the secondary cost of mounting and supporting them were gradually lowered, so that they soon came into a plane in which they could compete as to cost with bevel gears, chain drives, and other forms. When that stage was reached, it was but a short time before many other makers began to take them up, both for motor trucks and pleasure cars. To-day, there are at least a dozen reputable foreign makers, and more than that of American firms, using this form of gear with success. Moreover, its use is growing more rapidly than any other, unless it be the silent chain, which is not, however, finding favor for final drives where the worm gear has its strongest hold.

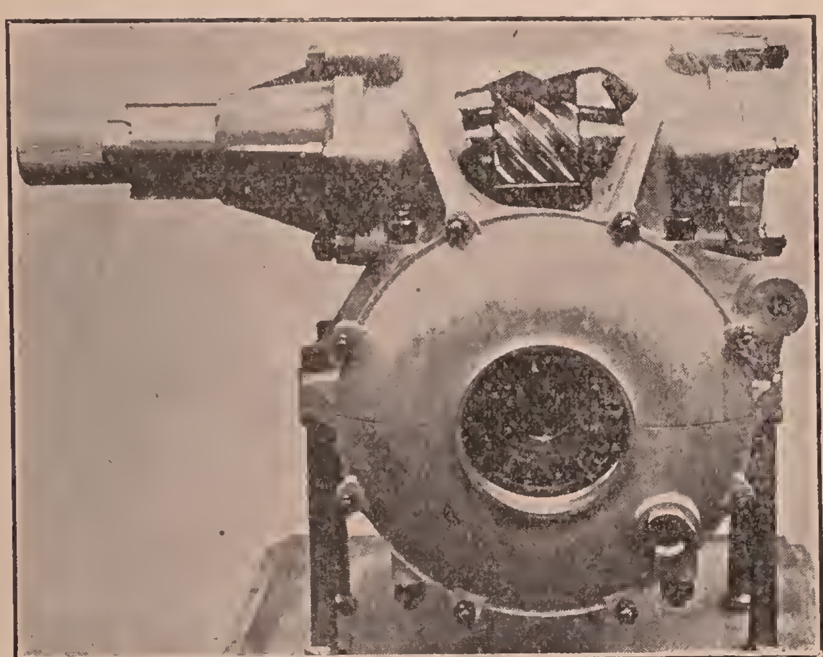

Fig. 169.—Worm Gear from DeDion Bouton (French) Car, Showing the Use of Worm Shaft Placed Above the Gear.

In the last year or two, they have made considerable progress in this country for use on electric cars, where they present a more silent drive than either the chain or the bevel. As the electric has been considered a particularly quiet car from the beginning, this added silence was desirable, so that this move is not to be wondered at. Fig. 168 shows a skeleton view of the Daimler-Lanchester type of worm and gear, as used on the 1914 Detroit electric cars. In this, it will be noted that the worm is placed below the gear. In this position, it gives a low center of gravity, allows of hanging the whole car very low, but primarily it keeps the worm covered with and running in oil. On the other hand, advocates of the overhead position say the form shown reduces the clearance so much that a car with it cannot be used outside of cities and paved streets.

As a basis for comparison, the newly developed DeDion-Bouton (French) form is shown in Fig. 169. This is of the overhead type, with an entirely different style of worm. Looking back at the Detroit, it will be noted that the worm has an hourglass or waisted form, the diameter at the ends being much larger

than at the center. In the DeDion form, on the contrary, the diameter is the same throughout its length. The hourglass form is supposed to give more surface in contact, and thus slightly greater efficiency. On the other hand, it is said to be more difficult to lubricate and to be subject to greater wear because of this greater surface of contact.

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**BEVEL GEARS** have improved remarkably in the last year or two, doubtless under the spur of the increasingly popular worm, with its numerous advantages. A form which has just been developed in this country for final drive is the so-called skew bevel, used on all 1914 Packard rear axles, and shown in Fig. 170. On close study, it will be seen that the teeth of the big bevel do not radiate from the center, as in the ordinary bevel, but have a curved shape, like a worm. The driving bevel has similar curved teeth. It is said that this form has a number of advantages all its own, with practically every advantage of both bevel and worm, excepting only the great reduction in speeds possible with small sizes.

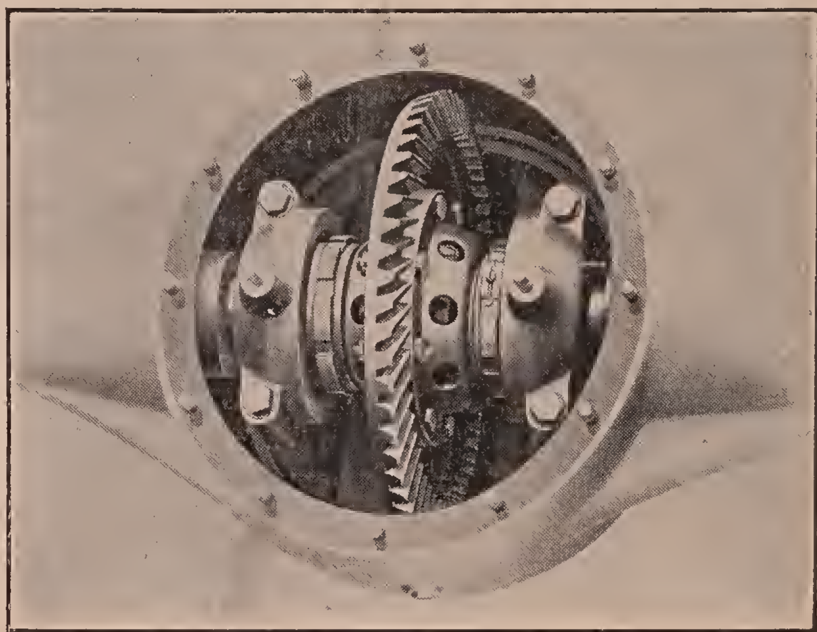

Fig. 170.—Worm or Skew Bevel Gears, Used on 1914 Packard Cars, Supposed to Have the Advantages of Both Worm and Bevel Forms.

The success of this form, an entire novelty developed by a firm which desired worm-gear advantages without the use of the worm itself, shows what can be done in motor car development, when study is devoted to any one part or series of parts.

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**THE SILENT CHAIN,** for driving various units on the car, has made equal progress in the last year, since it has become general knowledge that this allowed a freedom of placing of the units not possible with any gear or shaft form of drive which prescribed an exact location and an invariable one. With the chain, the units may be located to the best all-around advantage. Furthermore, it has been found equally efficient and more silent than gears, so that the substitution makes a more quiet car or motor. In Fig. 171 is shown the gear case as it would have been called a year ago of a new Darracq (French) motor. Silent chains have been used instead of two trains of gears, however, this making possible a better location of the shaft centers and a more desirable relation of the speeds of the three shafts than would be possible with gears.

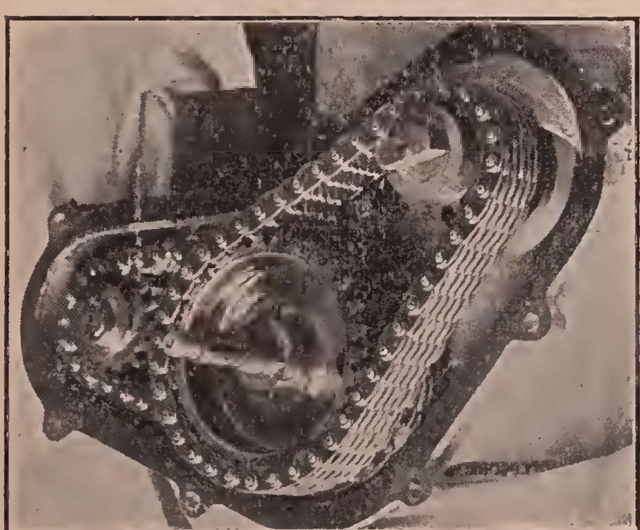

Fig. 171.—Camshaft and Auxiliary Shaft Drive by Means of Silent Chain, a Method Which Is Growing Rapidly in Favor.

In this case, the chain is used to drive the camshaft from the crankshaft at the lower left. Then, another sprocket on the camshaft drives the auxiliary shaft at the extreme right. Referring back to the Knight engine drawing, Fig. 158, it will be noted that the eccentric shaft is driven from the crankshaft by silent chain, Knight, as pointed out previously, having been one of the first to appreciate the use of the silent chain. In Fig. 161, the Carter piston valve engine, four different silent chains are used. One of these drives from the crankshaft to a pump shaft, thence another drives the magneto shaft, some 5 or 6 inches above it. A third drives an intermediate shaft about 7 or 8 inches up the motor's height, from which the fourth drives the

camshaft across the top of the cylinders and at least 10 or more inches above the intermediate shaft. Considering these distances, it will be realized at once how impossible it would have been to do this same work with a train of spur gears; it would have been necessary to use bevel gears and shafts, with numerous bearings, while the three different planes of action of the chains would have made necessary some very long and, in fact, projecting shafts. With these bevel gears, not less than twelve, or six pairs, being necessary, there would have been considerable additional trouble in working out just the right speed ratios.

If any further proof of the all-around benefits of the use of silent chains be necessary, the Mead engine, in Fig. 165, should be referred to. In this, the valve shafts—if they can be called that—are approximately 10 inches apart, in a horizontal line at the tops of the cylinders, and from 18 inches upward away from the crankshaft whence they must be driven. Consider for a moment what complications would ensue from trying to drive these two shafts from the crankshaft, using spur gears, bevels and shafts, or any method other than chains; consider what number of gears, shafts, bearings, lubricating devices, adjustments, etc., would be necessary, and the great advantages of the chain become apparent. The silent chain has all the advantages of the plain roller chain, with the additional, most important, feature of being noiseless, and through its possibilities in the way of extending its width indefinitely, of greater power-transmitting ability.

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**FOUR-SPEED TRANSMISSIONS** have been brought forth by the desire of car drivers to do everything on one gear—that is, without changing speed, as previously spoken of. While it may sound paradoxical to say that more speeds make less changing, yet such is the case. Where there are but two speeds to be had, as in the old form of planetary gear, everything must be taken on high or low, there is no alternative, and this requires that the low be very low, so that the engine would be able to pull the car up any kind of hill or heavy going. It required also that the high be not too high, for the very slowness of the slow speed made drivers loath to use it unless absolutely necessary. That being the case, it was necessary to have the high fairly low, in order that the driver would not stall his engine or be obliged to change to low at the very first slope or deep sand.

When three speeds came into use, it was possible to have a very low slow speed, so that the car could take any hill, no matter how steep, at a much higher high speed than before, and an intermediate. Now, with this combination and with a higher-powered and better-balanced engine than was the case previously, a driver was able to get his car in motion, and then keep to the high speed practically all of the time, except some very bad situation or for exceedingly steep hills. Knowing how to use his machine, such a driver rushed the hills, and in this way was able to make many on high which with the previous two-speed gear could not be accomplished on the low speed only.

With still more powerful and better-balanced motors, a large portion of them sixes, with an almost perfect balance as has been pointed out previously, it is possible with a four-speed transmission to divide the whole range of speeds into four parts (not necessarily equal parts, although some makers do this), and still have a direct drive on third or fourth as preferred, on which a clever driver can do as much as 90 per cent. of his work (excepting driving in city traffic, of course). And this is exactly what has been done; the best makers have responded each year to the demand for more power, better balance, and different gearing which would minimize the amount of gearing, until to-day we have in the six-cylinder motor with four-speed gear box a combination which allows the greater part of the driving, outside of the crowded city streets, to be done on one direct drive speed.

The question of silence has been mentioned many times previously; in the alteration of transmission gears, it has been necessary to produce a combination of gearing which could be used very widely—that is, a large part of the time—but which would be exceedingly quiet. No man minds a grinding of gears when

climbing a steep hill, going through deep sand, across a plowed-up road, or one that is being repaired, but a person cannot stand that all day. This being the case, it was necessary to provide one gear for general use, and on which the greater number of units would be out of use, and those necessary fairly quiet in action. Such is the direct drive.

On four-speed gears, some have two direct drives on both third and fourth, others have the direct drive on the fourth only—that is, the highest speed—while still others have it on the third or second highest speed, claiming this to be of the most all-around use. The first named brings in complications and weight; between the others, it is a matter of personal opinion and driving habits as to which is preferable.

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**THE TWO-SPEED REAR AXLE** used by one prominent maker in 1913, adopted by another of even more prominence for 1914, and promised on a number of high-grade cars for 1915, is the further working out of this matter of speeds. A two-speed axle gives in effect double the usual number of gear changes in the transmission, since each one of these may be used with both rear axle combinations. Thus, with a three-speed and reverse gear box, it produces six forward speeds and two reverse, while in combination with a four-speed gearset, it produces eight forward and two reverse rates of travel.

The principal idea of its adoption lies in economy of operation. Thus, for city work it is conceded that lower gearing throughout is highly desirable, since the slower speeds necessitated by heavy traffic may be produced in that case with a slower engine speed. As for example, a 4 to 1 reduction is better than a 3 to 1, since with the former a speed of 8 miles an hour can be produced with the engine running at a more reasonable rate than with the latter. This is as true of the intermediate and low speeds as of high. Further than the matter of reasonable engine speed is the necessity for gear changing with the greater reduction ratio—that is, with 3 to 1 gearing the driver would have to change down and up more times than with the lower 4 to 1 reduction. Since the engine can be run at more reasonable rates, and rates more in proportion to the actual travel of the car, fuel is saved. Consequently, the smaller (4 to 1) reduction is more economical as well as more convenient. A further point is that the slower the engine runs, the less the wear and tear on it, consequently the lower ratio scores again.

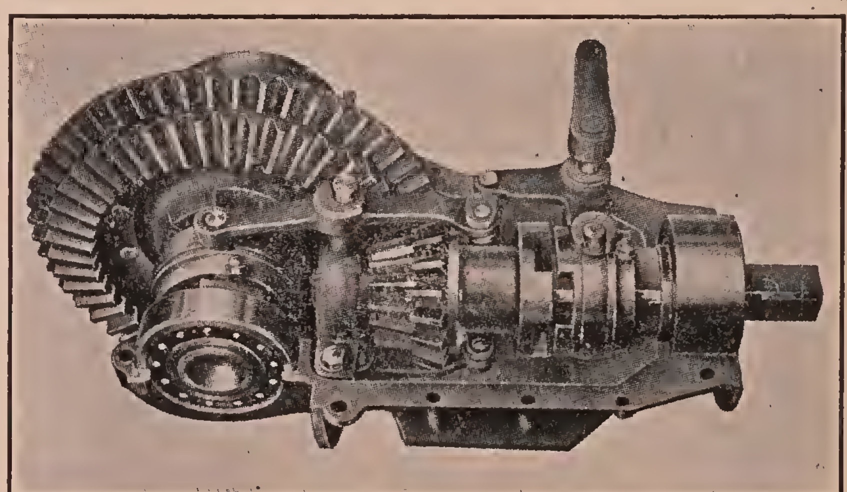

Fig. 172.—The Two-Speed Rear-Axle Drive of the Austin Car. By Means of Two Clutches, One Seen on the Driving Shaft, the Other on the Axle, the Proper Connections Are Made for the Two Drives, One Clutch Throwing Out When the Other Is Thrown in.

Granting, then, that a lower gearing is more desirable for city use than a high one, the proposition is reversed for the country. Here there is no traffic to wiggle through or worm around, no pedestrians to avoid, nothing but a straight road ahead. In such a situation, the greater gear reduction—that is, the one which gives the greatest car speed (3 to 1, as in the example above) is the most desirable one. Furthermore, it is the most economical one, for when the car is gotten into motion, when the driver has got "her" rolling, the car travels better, more smoothly, and with less fuel at a fairly high rate than at a lower one. In the country, then, the higher rates are more desirable.

With a single set of gearing—that is, with the ordinary three or four-speed gearset—it is impossible to have both, but with the two-speed rear axle the driver obtains both with all the advantages of the low rate in city and the faster travel in the country, also the economy at all times. The change from one to the other is made simply, in the case of the Austin, shown in Fig. 172, by pulling a short,

separate lever, and in the Cadillac by pressing a button, then throwing out the clutch and allowing it to engage again.

Another use of the two-speed axle is being forced to the front rapidly with the development of the cyclecar, and that is its use in that form of machine as a substitute for the transmission. The car is so small and light that few speeds are necessary, and it is simpler, more convenient and cheaper to use a two-speed axle than to utilize a separate transmission. In the cyclecar, every one of these points of lowered first cost, lighter weight, simpler construction, and greater convenience of construction and operation is of value, much more so than would be the case in a larger, more pretentious machine.

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**CAR SPRINGING** has undergone great changes in the past two years, due partly to natural refinement of the entire car, the springs coming in for their share, partly to the cry for increased comfort, and in no small part to the situation which was brought forth by higher power cars of longer wheelbase, carrying a greater load at a greater rate of travel, comfort being necessary whatever the load or speed. It might be supposed that the springs of ten years ago, when the maximum horsepower was about 12, the average wheelbase around 90 inches, the usual load but two persons, and speeds always below ten to twelve miles an hour, and even that not maintained for more than a few miles, would be decidedly different from those of to-day when powers range up to 80 and 90 in common use with 65 a fair average for big cars, with wheelbases from 125 to 145 and higher, with loads up to 7, 8 and even 9 persons in a car weighing, empty, as much as 4,500, and with speed possibilities on the high gear of from 5 to 65 miles an hour and comfortable riding at all of them, whether over city pavements or country roads.

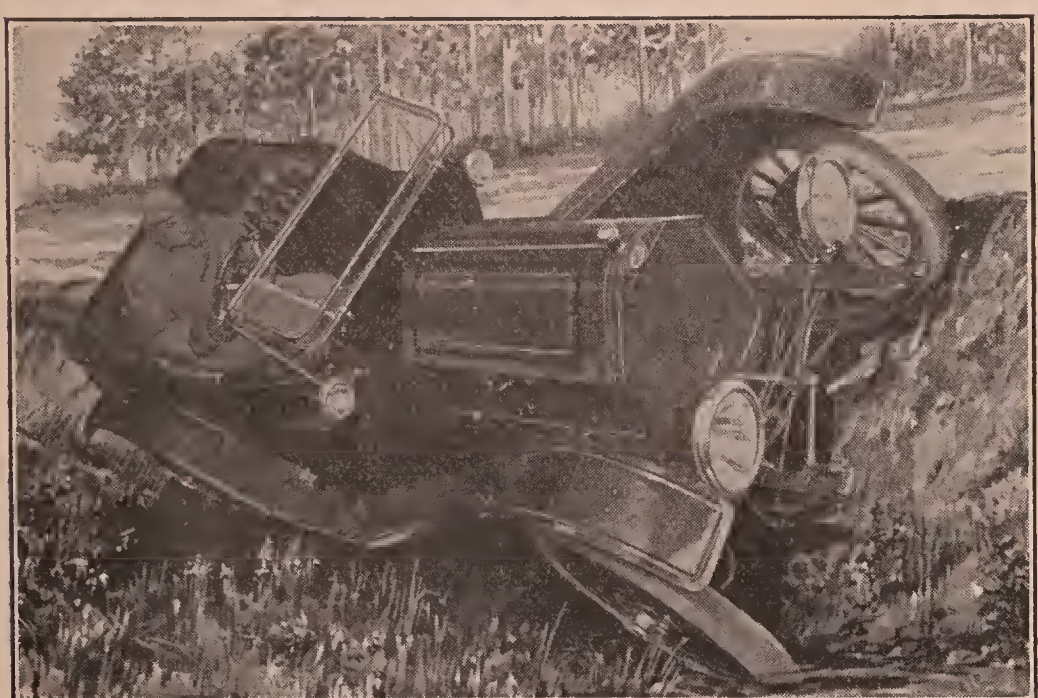

Fig. 173.—Entirely Underslung Car, with Frames Below the Springs, Ditched at an Angle of 60 Degrees to the Horizontal, to Show Stability of This Form of Springing.

Yet that is just what the spring makers have been obliged to contend with. The fact that they have not been entirely successful is not surprising, but this fact is evidenced by the large and increasing number of shock absorbers, shock preventers, bumpers, buffers, recoil absorbers, and similar devices put on even the best of cars, supposedly with the best of springs.

Any device which appears to promote easier riding of a car at high rates and a wide range of travel can get a trial to-day. Among the arrangements which are being tried with considerable success are the single-leaf cantilever spring, the double-branched or two-part cantilever, quarter elliptics for cycle and other small cars, underslinging of individual springs and all around the car partly to remedy the riding qualities and partly for other purposes to be mentioned later, coil springs alone and in combination with better-known forms, and a number of others, some of which might be classed as freakish.

Underslinging is used the most for the double reason, it is said, to make the car ride somewhat easier, and it brings the center of gravity and the center of mass of the whole vehicle down lower. Lowering these two last makes the car more stable at all speeds, since it hugs the ground more closely, while it renders the same almost impossible to tip over. With the best makers, the three-quarter

elliptic spring with the end of the upper member fastened to a plate formed by a projection of the main frame at the rear, and the lower member underslung, are the most popular. This type of spring reduces the height of the rear end of the car by at least four or five inches, the thickness of the spring plus the diameter of the axle housing. In some cases, where the latter is unusually large, it makes as great a difference as 7 or 8 inches. In addition, it is said to give greatly improved riding qualities.

When this construction is used, almost straight springs are utilized—that is, the springs have little or no camber, not to exceed an inch or two, as compared with from 5 to 9 inches usually necessary. This flatness is used at the urging of the spring men, who say that a very flat spring is not only better looking but has greater resilience and easier riding qualities than the same quantity and quality of material made up into a deeply curved spring.

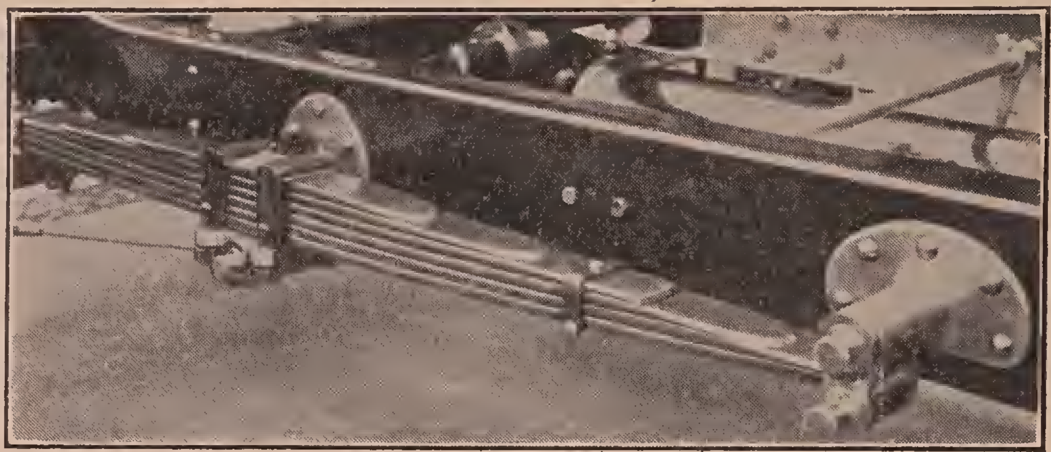

Fig. 174.—Cantilever Rear Spring, Which Will Be Much Used in 1914 and 1915, Because of Its Easy Riding Qualities and Side Sway Prevention.

As showing how underslinging all around lowers the center of gravity and makes the car difficult to tip over, Fig. 173 is offered. In this, a Regal car, in which the frame is hung below the springs, is seen on a bank with which it makes an angle of at least 50 degrees—60, the maker claims. Yet, it can be seen that even at this extreme position, the car is not in any immediate danger of tipping, and with the power on could be depended to pull itself out of this situation. Although not a stunt that anyone would care to attempt deliberately, it is worth knowing that one's car can stand that sort of thing, as it gives confidence when a considerable angle is attained in turning out for a team of something of that sort.

Of the cantilever type of spring, Lanchester in England was the first to use it, and many persons still call it the Lanchester type. This consists of a perfectly straight, or nearly straight, spring clamped to the rear axle at an inclination, its middle fixed in a clip of the side of the frame so that it can turn about this as a center—that is, the front can rise slightly and the rear drop equally, or vice versa, while the extended front end is shackled to the frame by means of an ordinary bracket and shackle. Obviously, there can be little or no action at the front end unless the rear moves, but any motion of the rear brings the central pivot into play and then the front shackle begins to work.

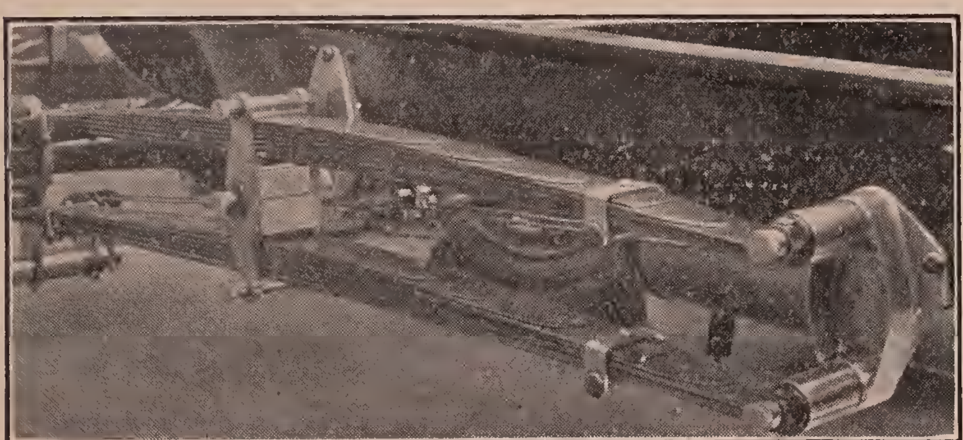

Fig. 175.—A Form of Double Cantilever Rear Spring, as Used on the Bayard-Clement, a High-Grade French Car.

The fact of the rear axle being attached to the rear end of the spring makes this portion of it act as a sort of radius rod, so that member may be omitted, saving weight and number of parts. The very shape of the spring and its method of fastening make side sway almost impossible, so that this form has an advantage over almost any other form of spring. Another point in its favor is that it is an exceedingly simple construction to look at and actually. The view of a spring of this type on a 1914 Berliet (French) car, shown in Fig. 174, gives a good idea of the arrangement. In this case, the rear end of the spring is fas-

tened on top of the rear axle, while in the case of the King and Pathfinder cars it is fixed below the axle, thus lowering the rear end slightly as compared with the method shown.

When the form just shown is made in double form—that is, with a pair of springs—the riding qualities are said to be even better than with the single form. The double type is used on the 1914 Clement-Bayard (French) cars, a photograph of these being reproduced in Fig. 175. Here it will be noted that instead of being attached either above the axle or below, as in the several cases just mentioned, it is fixed in both places. Similarly at the front end, where no shackle is used, the upper spring end being attached permanently to the upper pin and the lower member to the lower pin. The middle parts of the springs are separated by a correctly sized distance block, which is pivotally mounted on the frame so that the entire spring is able to turn about that point.

In this view, it will be noted that the previous construction is modified slightly in that the ends of the spring are thinner, of a less number of plates, and thus more flexible. That is as it should be, for with the fixing of the front ends, more flexibility is needed there.

A spring form being adopted for cyclecars and similar small vehicles is the quarter elliptic. This is often mistakenly called a cantilever, but it possesses none of the attributes of the cantilever nor the method of fixing which gave that form its name. While this type may be both flexible and strong, and actually is said to have excellent riding qualities, it does not look like one which would be very trustworthy. Its action is simple, the axle rising in an arc of a circle formed by the lower leaf of the spring straightening out as it rises. This action necessitates the use of a radius rod to guide the axle when rising and falling, and one will be clearly noted in the picture. When properly mounted on cars of 750 pounds weight and less, a pair of these in the rear, and in some cases four of them, used all around, are said to give easy riding and astonishing flexibility and resilience.

Taken altogether, it would be difficult to say that any one type, size, style, or make of spring now used under automobiles will be in use five years from to-day. Like all of the other parts of the car, the springs are undergoing a gradual transition, but from their influence on comfort, the springs are receiving more attention than any other one part of the car. Some progress has been made with air cushions, notably the Westinghouse, for attachment to the ends of present semi-elliptic springs; but this has not been sufficient to warrant the prediction that they will be widely used in the future, while at present their cost ($80 apiece, or $300 a car) is prohibitive and beyond what the results achieved with them would warrant.

**CONVENIENCE AND LABOR SAVING** is the keynote of the additions and refinements being made in the 1914 car. When air compressors are added, it is to save the back-breaking work of pumping up a tire by hand; it is so much easier to press a lever, throwing the compressor into engagement with the motor, then stand, gauge in hand, watching it do the work, than to do this same work slowly and laboriously yourself. Similarly, demountable rims and the carrying of an extra tire on a spare rim, fully inflated and ready for instant application with little or no work and not more than a few minutes' delay, are for the promotion of ease, comfort, and general convenience.

Wire wheels, now coming into general use, serve the same useful purpose, a set of five with five tires weighing no more than the usual four wood ones. In case of a puncture, the driver jacks up, takes off the offending member, puts on the spare wheel with its fully inflated tire, lets the car down onto it, and is off again, within five minutes of the time he punctured, and with little or no work. Even jacks have been made more convenient, easy to operate both up and down, with greater leverage so that not as much muscular effort is required to raise the same weight of car, and with the operating handle carried out to such a distance that it may be operated without stooping or bending under the car—that is, the present forms allow jacking up a car with a minimum of discomfort.

All the electric starting, lighting, and ignition devices have been improved to lessen work and increase comfort. The increase in the number of speed by four-speed gearsets and two-speed axles has been in the interests of less work and more pleasure. Similarly with the majority of new ideas.

Pumping up tires by motor has made the slowest progress of all, perhaps; why, it is difficult to explain. At present, however, it is making rapid progress In 1913, a considerable number of the best makers fitted small four-cylinder air compressors for this purpose, but it is notable that few of the 1914 product show multicylinder pumps, the great majority being of the single-cylinder type. Moreover, this addition has extended down into the medium and modest-priced cars, to an extent that almost warrants the prediction of universal pumps in 1915.

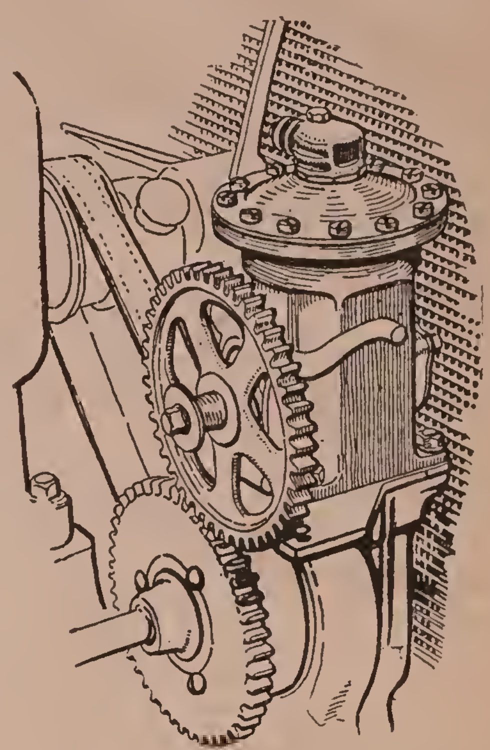

Fig. 176.—One-Cylinder Air Pump on the Cole Car Is Driven from a Spur Gear at the Forward End of the Motor.

Fig. 176 shows the form used on the Cole cars and a number of others, this being of a peculiar diaphragm type which will not allow any oil from the driving mechanism pass through with the air and thus destroy the rubber in the tires from within. Its drive will be noted; it is suspended at the front, close to the radiator, with its gear directly alongside of a gear on the camshaft. When air is required, pulling the lever seen at the right of the pump draws its gear over into mesh with the driver, and the pump starts to operate and to furnish the air required.

Another method of driving is indicated in Fig. 177, showing the construction used on the Pullman car. Here the pump is hung below and at one side of the flywheel, which has gear teeth cut into its periphery. The driving gear of the single-cylinder air pump may be swung into mesh with these by pulling on the lever and handle outside of the frame, this drawing the upper rod, which necessarily draws the vertical one, and since the right side of the pump is pivotally attached to the frame, the left side must rise in a circle about that point, and the gear teeth mesh. As soon as this is done, air is ready for use.

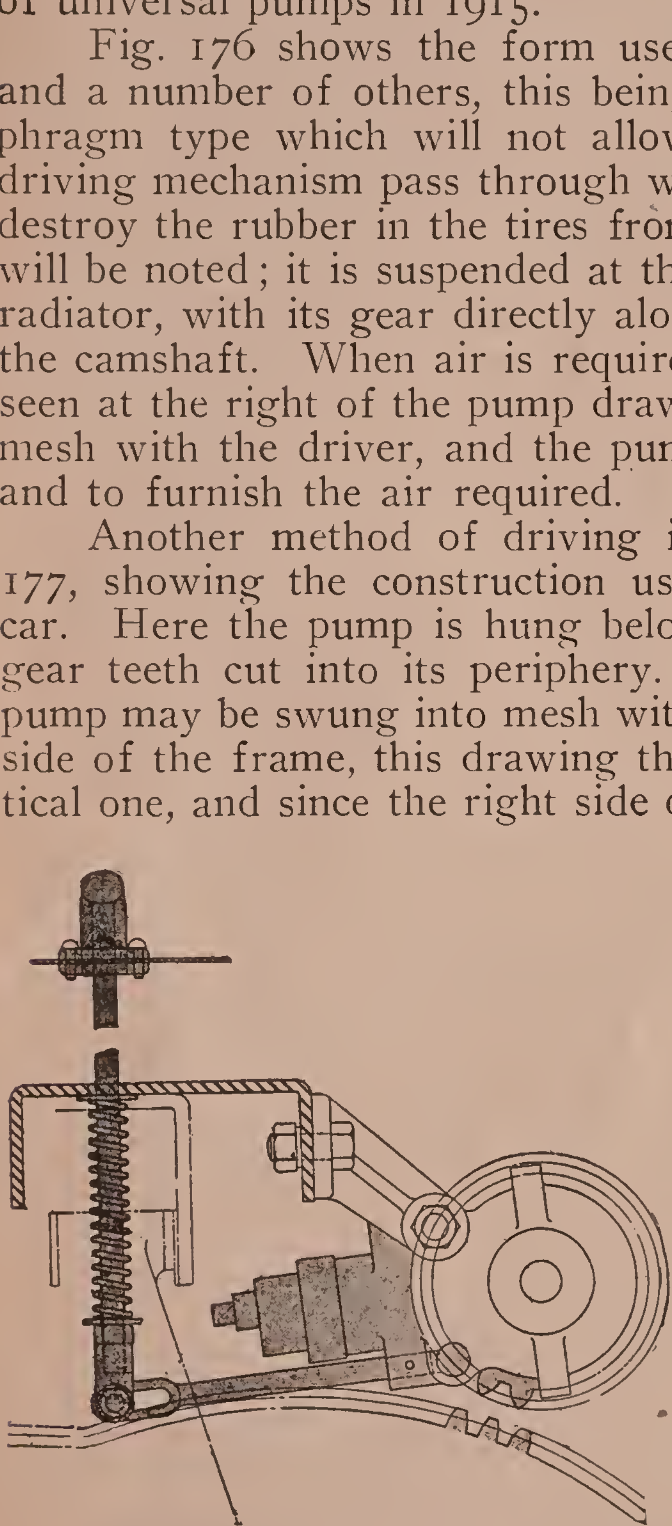

Fig. 177.—On the Pullman Cars, the Air Pump Hangs Below and to One Side of the Flywheel. When Needed, a Rod Pulls It Over So That Its Gear Meshes with Teeth on the Rim of the Flywheel.

In the French design, shown in Fig. 178, a more simple yet decidedly novel arrangement is seen. Here the pump of the single-cylinder form is incorporated in the cover of the gearbox. It is not connected up, however, but has a small clutch by means of which it is thrown into and out of engagement. At the side of the car, on the frame, is a round metal box, apparently with a hinged cover. Opening this, one finds a lever at the top which throws the clutch into engagement so that the pump will begin to work, while below is found the air pipe to which the hose is attached for conducting this air to the tire which is to be inflated. This is perhaps the most compact, the neatest, and most sensible arrangement shown. Sometimes the pump is attached to the extended front end of the camshaft with a finger lever for throwing it into mesh and out again. To use the pump, the hood is raised, and the lever thrown over.

By locating the speedometer gears on the front axle, considerable noise results, as well as a poor-looking arrangement. Designers have begun to get away from both, but it has necessitated many ingenious methods. One way has

been to drive the speedometer shaft through the center of the axle spindle on which the wheel turned, thus doing away with the exposed gears and their noise, but making the all-important spindle more complicated and possibly weaker because of the hole through it. Another method which is meeting with much favor is the application of a gear to the main shaft, just back of the transmission, and driving the speedometer from this. It has the advantage of being under the body, where it does not collect dust or dirt, and where its small noise is not magnified by sounding boards like the front fenders. In addition, this position puts it where it cannot be tampered with readily, where it cannot be injured in any ordinary collision, and where the length of shaft required to drive it is as short as possible.

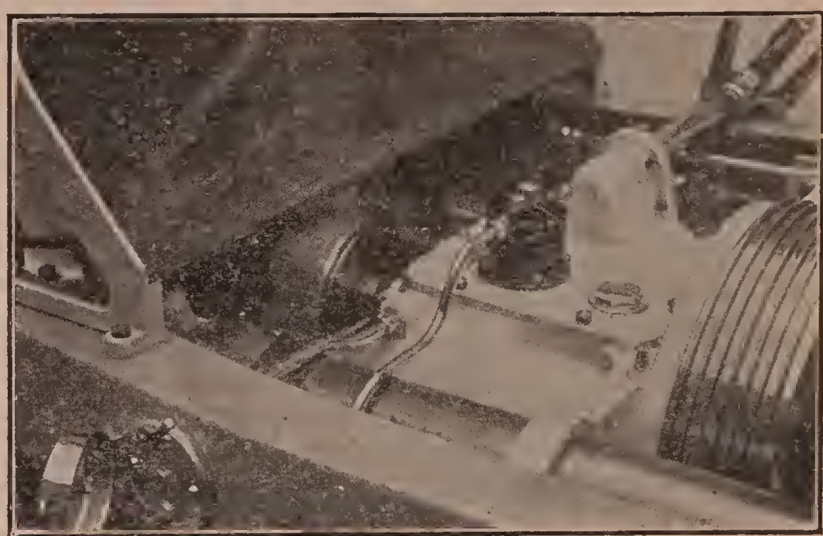

Fig. 178.—Handy Location of the One-Cylinder Air Compressor in the Gear Box with Lever Operating the Clutch, and Air Pipe Outlet Cleverly Covered by Round Metal Disc at Side of Frame.

When the transmission is not made a unit with the engine and clutch, and this construction is used, the speedometer gear is placed right back of the clutch. In this position, on practically all cars, it is directly beneath the dashboard, where all speedometers are placed now. Consequently, all the shaft that is required is a simple straight length of perhaps 28 to 30 inches, reaching in almost a straight line from the driving gear to the instrument on the dash. In addition to making the shaft short, simple and inexpensive, this has the advantage of accuracy, for the shorter and straighter the shaft, the more accurately it works, and the less danger there is of its getting out of order.

In general, the cars of 1914 are characterized by simpler lines, more efficient and powerful motors, more comfortable and easy-riding springs, frames, wheels, tires, and upholstery, while the labor and care of operation is reduced to a minimum. The cars are made better throughout, of superior design, better materials, fashioned better and fitted together in a more careful and accurate manner. For these reasons, they are less liable to the accidents, derangements and lack of adjustment noted on the early cars. Taking it all in all, the cars are as cheap in price as may be expected, and present as great or greater value in each case than ever before. In fact, the greatest trouble for the man deciding to buy a 1914 motor car is the decision as to which make he should choose of the many offered at the price he is prepared to pay, so good are all of them.

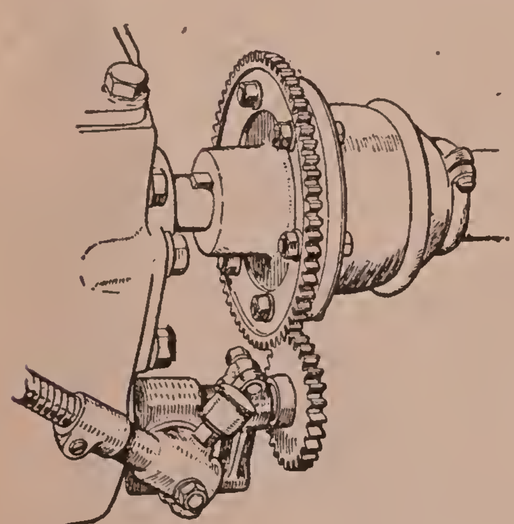

Fig. 179.—Speedometer Drive from the Main Shaft Instead of the Front Wheel (Cole Car).

This concludes the last chapter of "What Every Owner Should Know About His Automobile." We have endeavored in a most impartial way to cover every point of special importance on the motor car. Our principal aim has been to help the motorist in a practical way to a better understanding of his car—which makes for more enjoyable motoring, a lower cost of upkeep, and longer life of the car. We hope we have succeeded in our efforts.

THE END.